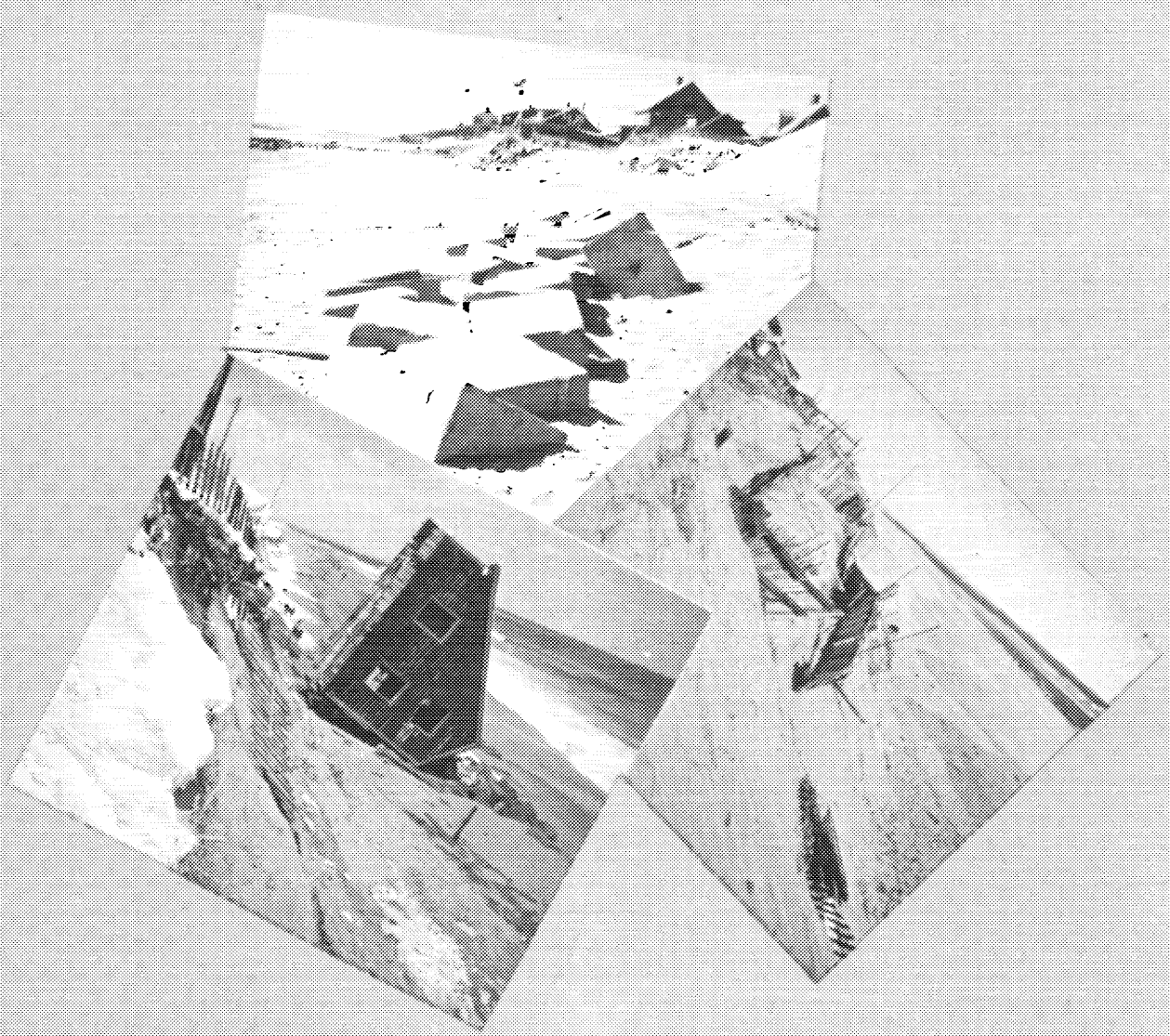
PLUM ISLAND BEACH

Feasibility Report

Newburyport - Newbury, Massachusetts



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS

DECEMBER 1976

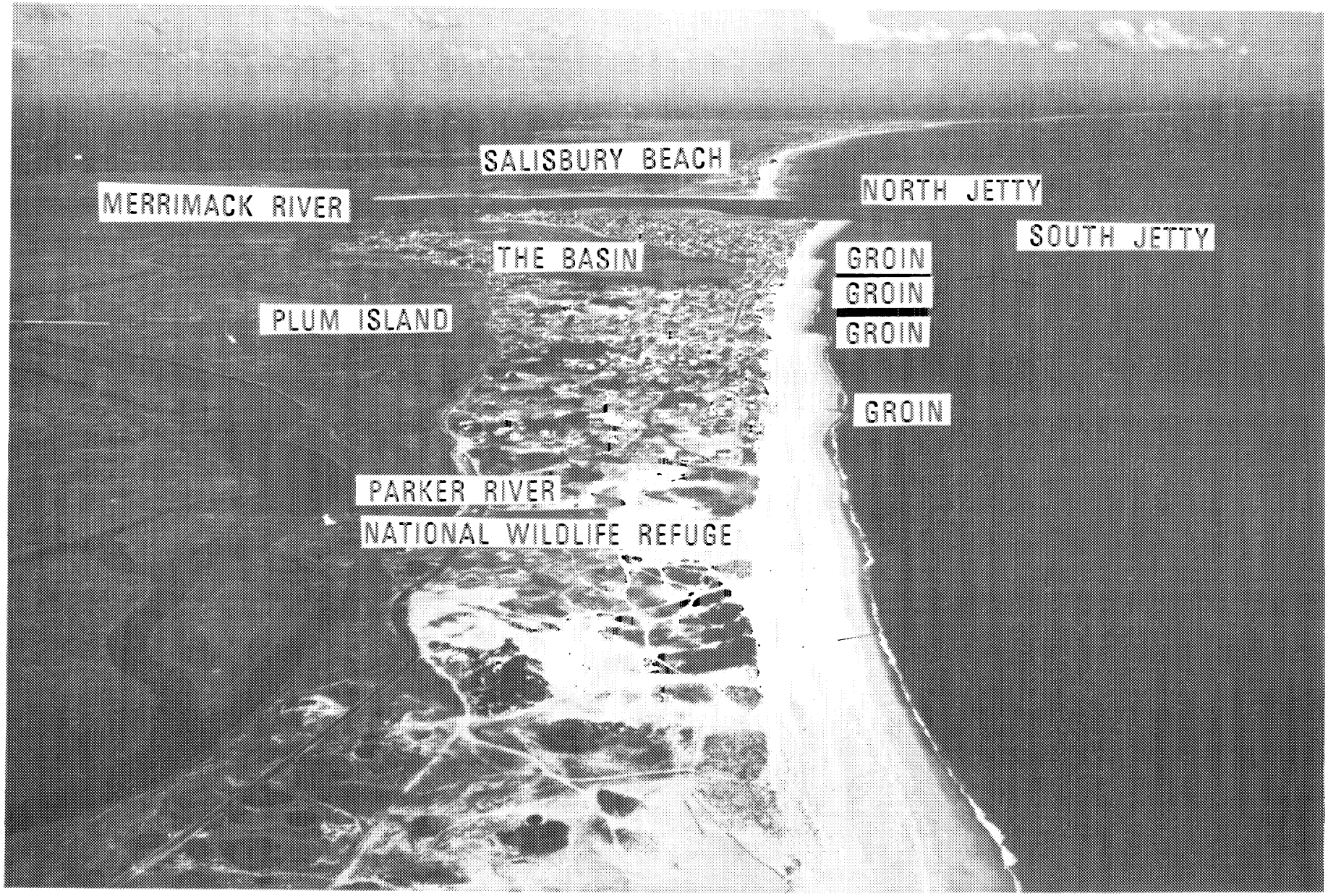


Photo 1. Looking North, at Mid-Tide in August 1962, note the buildup of sand along the south side of the groin structures.

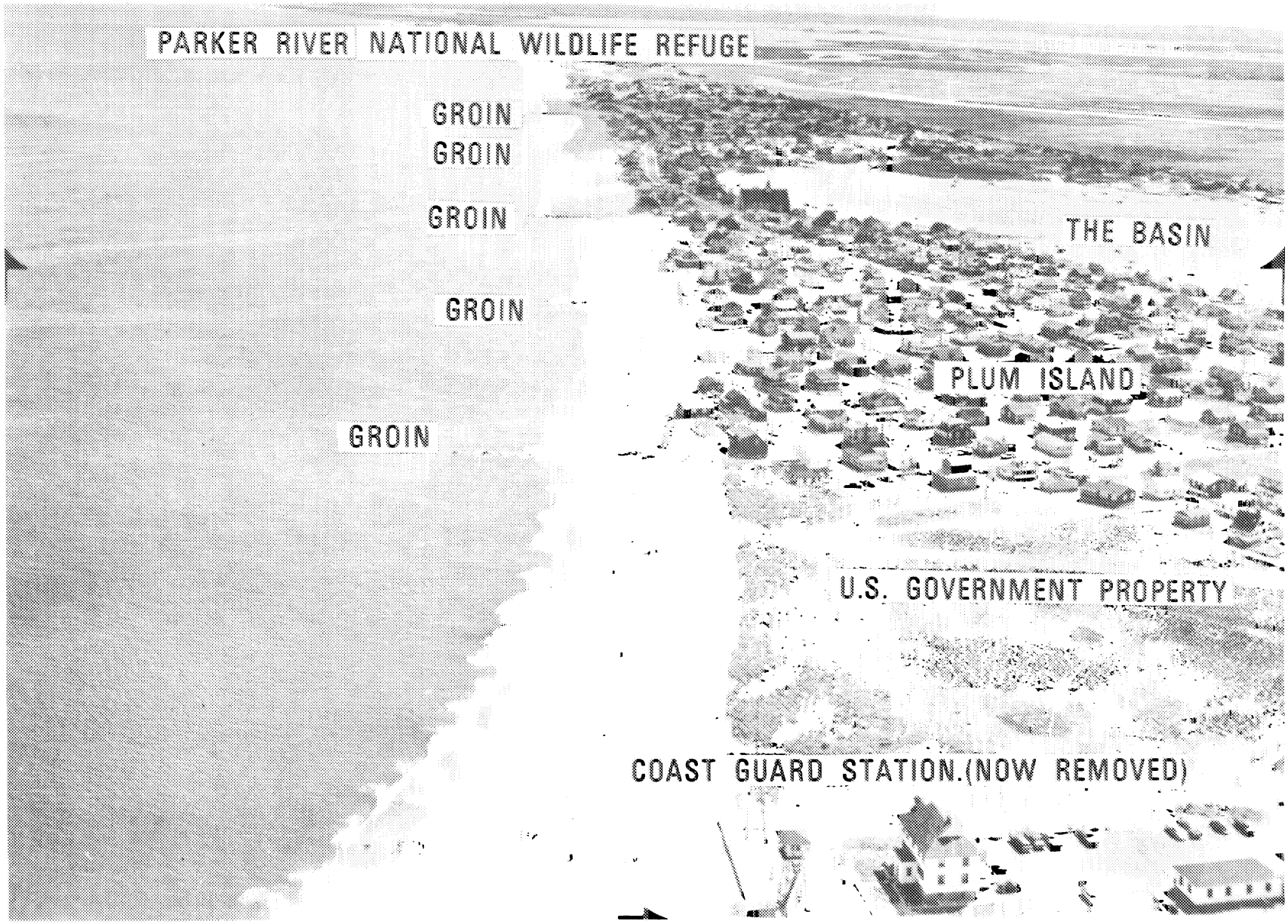


Photo 2. Looking south from the Merrimack River at about mid-tide in August 1968

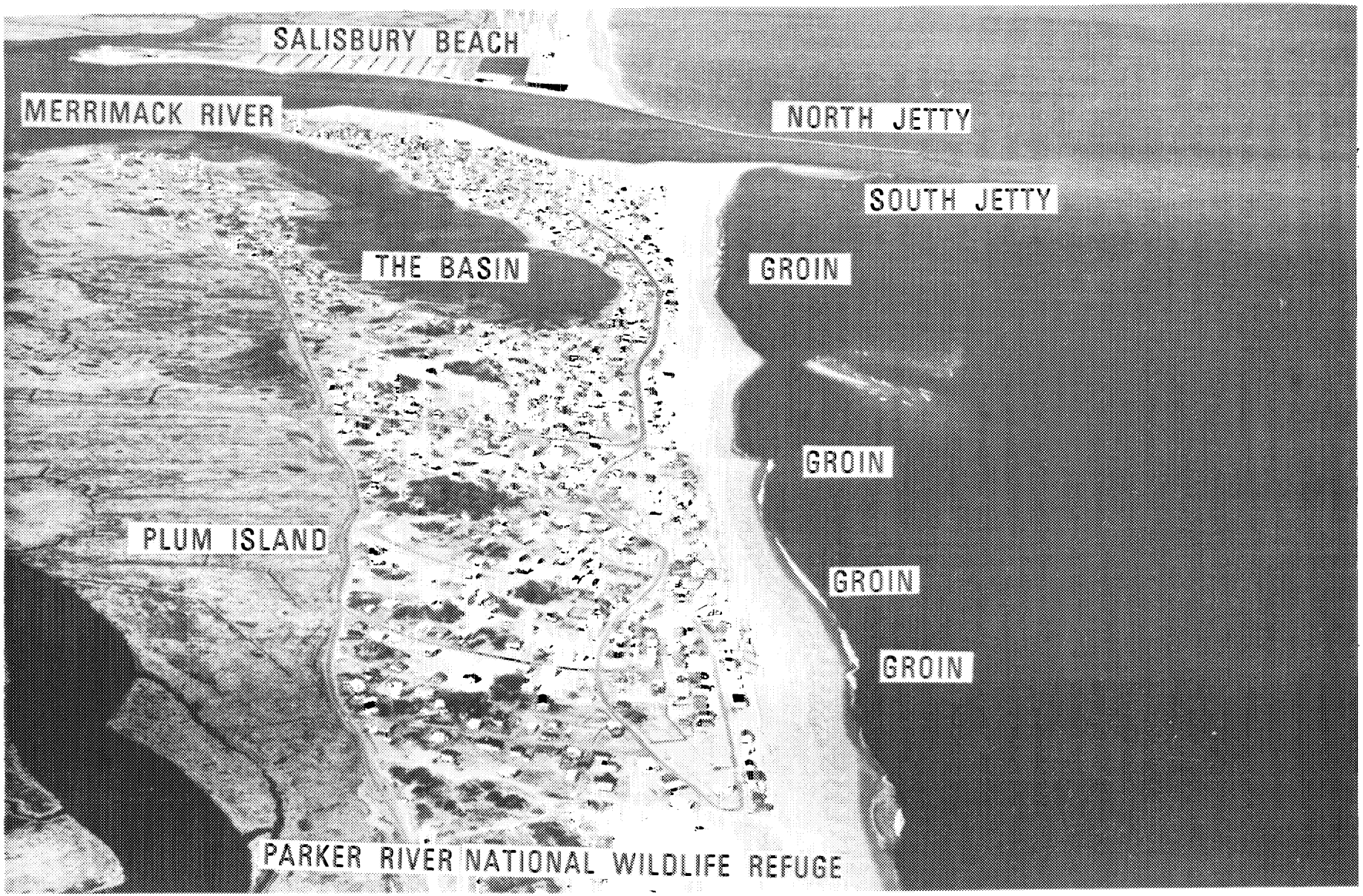


Photo 3. Looking north in March 1974 note the irregular shape of the shoreline.

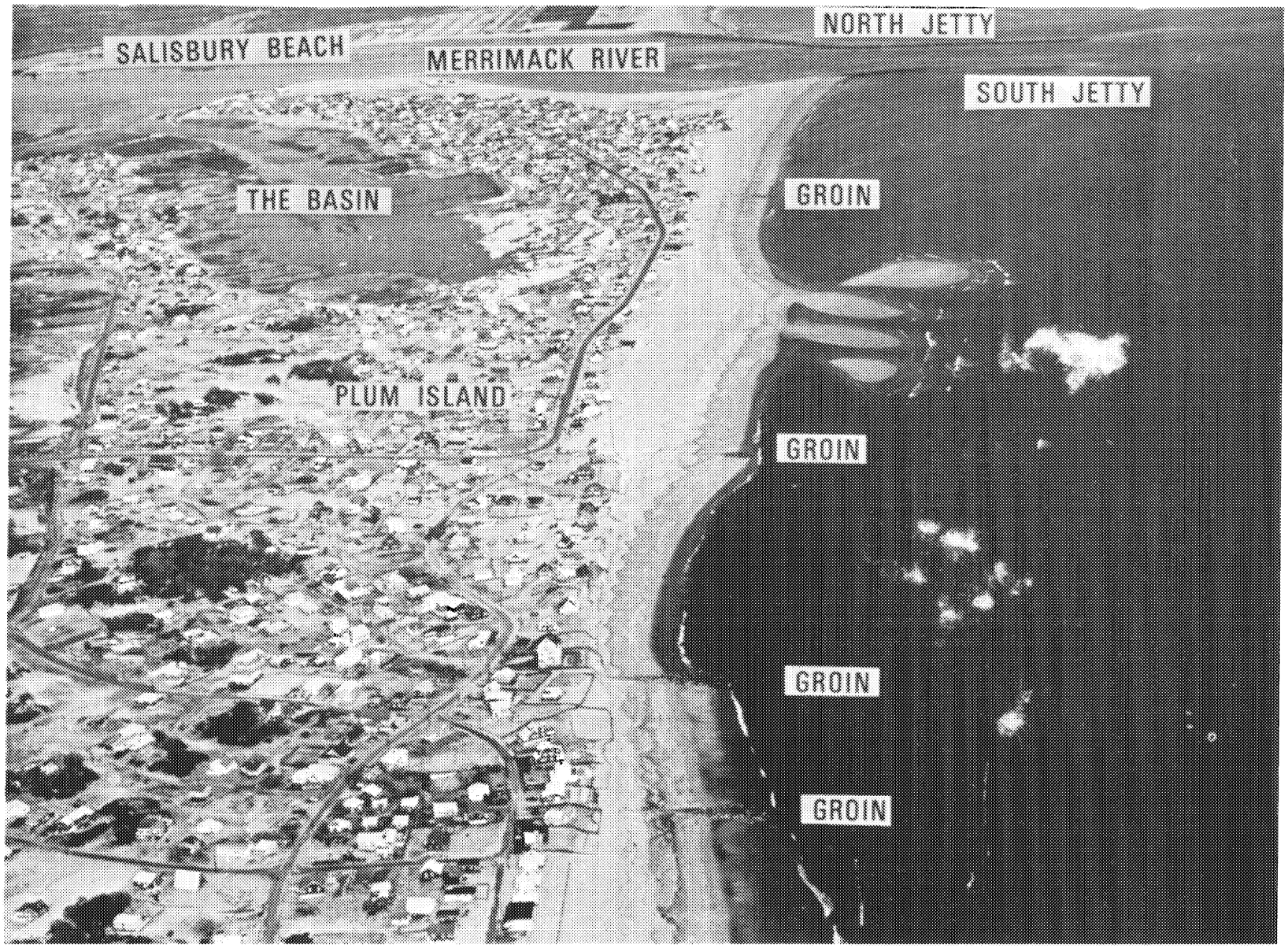


Photo 4. Looking north during mean low water in February 1976. Note the erosion and the accretion. As a result of several storms in February 1976.

SYLLABUS

The purpose of this beach erosion control study was to investigate approximately 4.7 miles of shoreline starting on the south bank of the Merrimack River and extending south along the shoreline of Plum Island to the Newbury-Rowley town line to determine the economic, technical and environmental feasibility of providing improvement and protection measures.

The Plum Island shoreline is subject to erosion and flood damage from wave attack during severe northeast winter storms. Several plans of protection involving structural measures were evaluated to determine how well they met all of the economic, environmental and technical criteria involved. In addition a number of non-structural measures which can be taken by local officials and private property owners were discussed to show how they can be effectively used either in conjunction with the structural measures or on their own to help reduce the amount and extent of storm wave and flood damage which may be expected to occur.

The study has revealed that none of the plans of improvement which were evaluated met the economic criteria necessary for Federal participation and cost sharing in an improvement project.

It is therefore recommended that in light of the lack of economic justification, no beach erosion control project be adopted by the United States for providing protection against erosion and storm damage along the Plum Island shorefront.

It is further recommended that non-Federal interests plan and undertake as soon as possible, if they have not already done so, all the appropriate non-structural measures which have been discussed in this report.

PLUM ISLAND BEACH
NEWBURYPORT AND NEWBURY, MASSACHUSETTS

FEASIBILITY REPORT

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FEASIBILITY REPORT

THE STUDY AND REPORT

Since early times the ocean has been a focal point for mans activities. It has been used as a food source, a source of employment, a means of transportation and as a source of entertainment and enjoyment by providing for mans recreational boating and bathing needs. The shoreline of Plum Island has been used intensively by the permanent and seasonal residents as well as the transients who visit the island on a daily basis for sunbathing, swimming, fishing and boating. As is true of much of the land along the Atlantic coastline, the northern portion of Plum Island has been highly developed and is continually under pressure for additional development brought about by mans relentless pursuit of oceanfront development. However desirable oceanfront development is, it also has certain problems associated with it. The coastal shoreline is continually susceptible to the forces of nature such as winds, waves, currents and tidal action which can cause serious erosion problems with the accompanying loss of recreational beach area, private property, structures and in some severe cases the loss of life. These forces are extremely intense during periods of extra-tropical storms, hurricanes and severe northeasters. These events of coastal erosion and extensive storm damage are present to a significant degree along the Plum Island shoreline.

Purpose and Authority

In recognition of the above problems and the associated environmental concerns, the Committee on Public Works of the United States Senate, at the request of local interests made through their representative in Congress, adopted a resolution on 29 March 1973 requesting the Board of Engineers for Rivers and Harbors to review the report of the Chief of

Engineers on a cooperative study for beach erosion control of Plum Island, Massachusetts published in House Document 243, 83rd Congress, and other pertinent reports, with a view to determining whether any modification of the recommendations contained therein are advisable at the present time in the interest of beach erosion control and allied purposes.

Scope of Study

The study, which is contained in this report, deals with the Plum Island shorefront beginning on the south bank of the Merrimack River along the property owned by the United States Coast Guard and extending south along the shoreline to the Newbury-Rowley town line a distance of approximately 4.7 miles as shown on Plate No. 1. In the past, most of the critical erosion has been experienced in the area from the U.S. Coast Guard property at the mouth of the Merrimack River southward to about the beginning of the National Wildlife Refuge a distance of approximately 2.0 miles. The emphasis in this report has been placed on this northern portion of the island. Investigations were conducted to determine the best measures for protecting this area against storm damages and erosion; the accompanying costs and benefits associated with these measures; and the impacts associated with these measures.

The Report

In the interest of clarity, brevity and ease of reading the contents of this report has been arranged into a main report and six appendices. The main report is a brief, nontechnical presentation, describing the results of the feasibility study for beach erosion control and allied purposes for the shoreline of Plum Island, Massachusetts. Four of the appendices: Considered Plans of Improvements with Attendant Costs and Annual Charges; Estimates of Benefits, Social and Economic Effects Assessment from Improvement; Description, Composition of Shore and Protective Structures contain the backup technical data associated with the information contained in the main report. Appendix C describes measures which can be employed by local interests to reduce erosion and storm damage. Appendix F contains all the pertinent correspondence in connection with the study,

Prior Studies and Reports

A beach erosion control report for Plum Island was completed in 1952 by the Corps of Engineers in cooperation with the Commonwealth of Massachusetts and is published as House Document No. 243, 83rd Congress, 2nd Session. This report recommended no Federal participation in the cost of the beach erosion control improvements for the overall Plum Island area because the shore was privately owned. It did, however, recommend that protective measures be undertaken by local interests in accordance with a plan developed in the Federal study; which recommended placement of about 285,000 cubic yards of suitable sand fill along the beach, and raising the shore end of the south jetty at the Merrimack River to 16 feet above mean low water. In addition to the 1952 study, a design memorandum on rehabilitation of the north and south jetties at the entrance to the Merrimack River completed in 1965, did result in the sealing and raising of the south jetty. The work was completed in 1969.

In 1967, a reconnaissance study was made pursuant to Section 103, Small Beach Erosion Control Authority, for the northerly Plum Island shorefront. It determined that the needed beach erosion control improvement project exceeded the $1,000,000 Federal expenditure limit. Consequently, officials of the State, city of Newburyport, and town of Newbury were advised to seek a congressional resolution to complete the study.

In 1969, following a series of severe winter storms that caused extensive erosion along the south shore of the mouth of the Merrimack River, a special study was completed which recommended that a revetment be placed along the shore in the vicinity of the U.S. Coast Guard Station to protect it from being lost, and to protect the Federal south jetty structure from being flanked. The work was done in 1970.

In 1973, a detailed project report was prepared to provide a protective and recreational beach as an emergency measure along the seriously eroding sector of the residential and commercial shorefront of Plum Island starting at the turnpike groin and extending north along Northern Boulevard for a distance of 800 feet. The recommended plan of protection and improvement consisted of dune restoration and embankment reinforcing along 800 feet of the backshore fronted by a protective beach formed by direct placement of suitable sand fill furnishing a level beach berm of 75 feet in width at an elevation of 15 feet above mean low water. The top elevation of the dune is 24 feet above mean low water. This most recent work was completed in April 1973.

RESOURCES AND ECONOMY OF STUDY AREA

In many instances the natural resources of a region play a significant part in determining the social well-being of the people in the area and are helpful in identifying its problems and needs. The development on Plum Island is mainly residential in nature and most of the activity in the area is centered around bathing, fishing and recreational boating. Plum Island is located partly in the city of Newburyport and the towns of Newbury, Rowley and Ipswich and is approximately 40 miles north of Boston in the northeast corner of Massachusetts. Very little economic activity takes place on Plum Island. There is no manufacturing activity on the island. Commercial activity consists of restaurants, food shops, fishing tackle shops and two boat rental businesses. The year-round residents, therefore, work either in the city of Newburyport or the town of Newbury, or travel farther distances to communities within the Boston Standard Metropolitan Statistical Area (SMSA) and surrounding labor market areas of Lowell and Lawrence.

The Atlantic Ocean is the major water resource in regard to swimming activities in eastern Massachusetts Although Massachusetts coastal strip is richly endowed with numerous miles of irregular and indented coastline which provides many sheltered and sandy beaches, the increasingly intensive use of these water areas has created problems. In general, the major problems are a lack of public access and polluted waters which limit the use of many water areas. At Plum Island, the particular problems of erosion and extremely restricted parking facilities have contributed to the under-utilization of this resource. (For details see Appendix B.)

Natural Resources

The shoreline of Plum Island is approximately 8 miles in length and consists of a sandy coastal barrier bar largely covered with dunes along the southern two thirds of the island. The northern one third of the island, within the limits of the city of Newburyport, and the town of Newbury, has residential and commercial development. The southern portion of the island within the limits of Newbury and Rowley, contains the Parker River Wildlife Sanctuary under the jurisdiction of the U.S. Fish and Wildlife Service. A state park is located at the southern tip of the island within the limits of the town of Ipswich. (See Plate 1.)

All along the Atlantic coastline there is continued pressure and demand placed on the water resources to provide for the salt water bathing, fishing and recreational boating needs of the populace. In general, the major problems of a lack of public access and water quality have limited the use of the water resources in many coastal areas. At Plum Island, the particular problems of erosion and extremely restricted access and parking facilities have contributed to the under-utilization of this resource. The Plum Island Turnpike is the only road linking the mainland to the island and beach going traffic rapidly builds up by midmorning on peak summer days. Much of this traffic goes into the wildlife refuge. After 400 cars have been admitted, the refuge has reached its parking capacity and traffic then becomes very congested on the residential part of the island. (See Appendix B for details.)

Human Resources

In 1970, the population of Massachusetts, one of the most urban states in the nation, was 5,706,776. Of this 3,787,384 persons or 66 percent were concentrated in the Eastern Massachusetts Planning Region which includes Plum Island and is centered on the city of Boston.

The 1975 population for the city of Newburyport was 16,300 and 4,223 for the town of Newbury. The permanent year round population for the developed section at the north end of Plum Island is approximately 1,300 for the Newbury portion and 539 for Newburyport. The combined total of 1839 people represent 9.0 percent of the total population of Newbury and Newburyport. During the summer season the population increases to approximately 6,200. In recent years there has been a definite trend in converting summer residences to year round residences. Year round population has increased from 100 in 1950 to the present 1839.

Residential property on Plum Island is very attractive for people wanting to spend their leisure time or even retirement years in a coastal environment. Some of the reasons for the growing attractiveness of property on Plum Island is its relatively moderate climate, proximity to Boston and the recent moratorium on construction on the island. (See Appendix B for details.)

Development and Economy

Since 1950 Plum Island has experienced a rapid rate of development and conversion of seasonal residences to year round residences. As was mentioned early during the summer months the population of the island

increases by more than three times its normal level. This additional increase in population causes traffic problems and puts extra demands on the enforcement of health regulations as well as placing extra stress on adequate fire protection. During a busy summer day, it is very difficult for fire equipment to pass through the area quickly. In addition the fire department must transport water onto the island since there is no available supply for fire fighting.

Neither the city of Newburyport nor the town of Newbury is encouraging the growth on Plum Island. In the past, the size of the average lot was 70' by 70'. Over 90% of the existing residential lots are of this size. Today, the zoning regulations require that lots must be at least 100' by 100' in order for each residence to safely maintain a water supply and septic system. It is now necessary to buy two lots in order to build a residence and be in compliance with the zoning regulations. The island has just recently been rezoned 100% residential but, under the "grandfather" clause the existing commercial establishments which include restaurants, food shops, fishing tackle shops and two boat rental businesses are allowed to continue in operation. There is no industrial or manufacturing activity on the island.

Even with all of the problems confronting Plum Island, property on the island is in great demand. The median price range of homes on the island is between $24,000 to $30,000. The relatively attractive price range of homes, the moderate climate, its proximity to Boston, the moratorium on construction, and the recreational opportunities afforded by the island all add to its appeal. (See Appendix B for details.)

PROBLEMS AND NEEDS

The problems and needs which are discussed and addressed in this report deal with the flooding and related damages which occur during severe storms caused by natural forces and the loss of recreational beach area. These issues are discussed in subsequent pages of this report as well as considered plans to alleviate these problems, the impacts of these plans and the way in which these plans address the desires of the local interests.

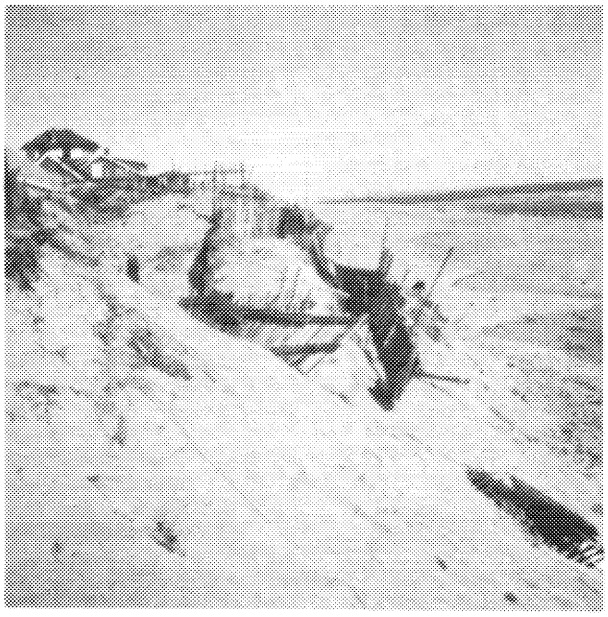


Photo 5. Looking at seriously eroded dunes, located about 6,000 feet south of of south jetty. Storm waves approach the base of this dune causing loss of valuable backshore dunes.

Photo 6. Cottages damaged as a result of a series of storms. This damage occurred in March 1976 and is located about 1,000 feet south of the Turnpike Road.

Photo 7. PLUM ISLAND 1966. Looking northerly of Plum Island Turnpike groin along wide protective beach and dunes that existed prior to the 19 February 1972 storm. Note this section of shore eroded as a result of a series of storms in 1972 (See Photo 8)

Photo 8. PLUM ISLAND 1972. Looking north from turnpike groin after 19 February 1972 storm. Wide beach and protective dunes formerly fronting backshore homes were destroyed by storm. See Photo 7.

Photo 9. During September 1972 storm this structure was seriously damaged by the storm. This structure is located at the end of the Turnpike Road.

Photo 10. PLUM ISLAND 1966. In 1966, problem area existed along about 3000 foot sector located about 4,000 feet south of the South Jetty. The State constructed a section of revetment here and at other sporadic locations to the north.

Photo 11. December 1974, this sector of the Plum Island shoreline formerly eroded away (see photo 10) now a wide healthy beach exists naturally, no artifical sand was placed on the beach.

Description

The total ocean shoreline of Plum Island is about 8 miles in length. Plum Island is a sandy coastal barrier bar largely covered with sand dunes along its southern two-thirds. In places these dunes extend as high as 50 feet above mean sea level. The bar is separated from the Plum Island River to the west by a marsh which is generally greater in width than the bar. The bar varies in width between one-tenth and four-tenths of a mile and averages one-fourth of a mile in the area south of "The Basin", a body of water extending southward from the Merrimack River Estuary. The bar at its narrowest point is about 350 feet wide. The maximum width is about six-tenths of a mile at the Merrimack River. Residential and commercial development is concentrated at the northern portion of the island within the limits of the city of Newburyport and the town of Newbury a distance of approximately 2 0 miles. The development includes cottages, churches and commercial establishments. The remainder of the island to the south, with minor exceptions, is set aside as a Federal wildlife sanctuary operated by the U.S. Fish and Wildlife Service. Access to the island is furnished by the Plum Island Turnpike, which runs from the city of Newburyport to Northern Boulevard, the only surfaced road on Plum Island, leading to the development on the north end. The area under study is shown on National Ocean Survey Charts Nos. 13278 and 13282, the Newburyport East Quadrangle of the U.S. Geological Survey and drawings accompanying this report. This report will deal only with the north portion of the island starting on the south bank of the Merrimack River along the property owned by the U.S. Coast Guard and extending south along the shoreline to the Newbury-Rowley town line, a distance of approximately 4.7 miles. (See Plate A-1 in Appendix A.)

Statement of the Problem

The overall problem is generally one of progressive erosion of the ocean shorefront seaward of the cottages with losses of fronting beach and protective dunes at various locations along the northern one-third of the island. The erosion has been particularly severe

during major storms and has resulted in losses of cottages, serious reduction in lot sizes and the total loss of some seaward lots. Many cottages have been moved landward as far as possible and are now bordering Northern Boulevard. The southern two-thirds of the island does on occasion experience erosion problems but in general has remained fairly stable.

At this time the Plum Island shorefront is experiencing severe erosion problems in two areas. One area of concern is along the south shore of the Merrimack River which is owned by the U.S. Coast Guard and the other is a section of beach starting at the turnpike groin structure and extending southward to the next groin structure a distance of approximately 1200 feet. This latter section of privately owned shorefront has experienced significant erosion during severe winter storms in late 1975 and early 1976 and some of the homes located along the backshore fronting this area are in danger of being lost if the erosion is allowed to continue.

Factors Pertinent to the Problem

A number of factors and natural forces have helped to shape Plum Island as it is today. These factors and forces have been continually interacting to bring about the changes which have occurred on the island throughout history. The following sections contain a discussion of these pertinent factors and forces.

Geomorphology

The shoreline of Plum Island is one of emergence of the land with respect to the level of the sea. The island is almost entirely composed of sandy beach deposits in the form of a barrier bar covered with high dunes fronting extensive marshes. The beach and dune materials are

Photo 12. April 1969 Coast Guard Station in the background. Top of bank is now 45 feet from station. Spring tide approaches base of slope. Note - since this photo, the station has been removed and the shore revetted - (See Photo 21).

Photo 13. April 1969 Looking west along the south shore of the Merrimack River. Note eroding bank vicinity of the Coast Guard Station.

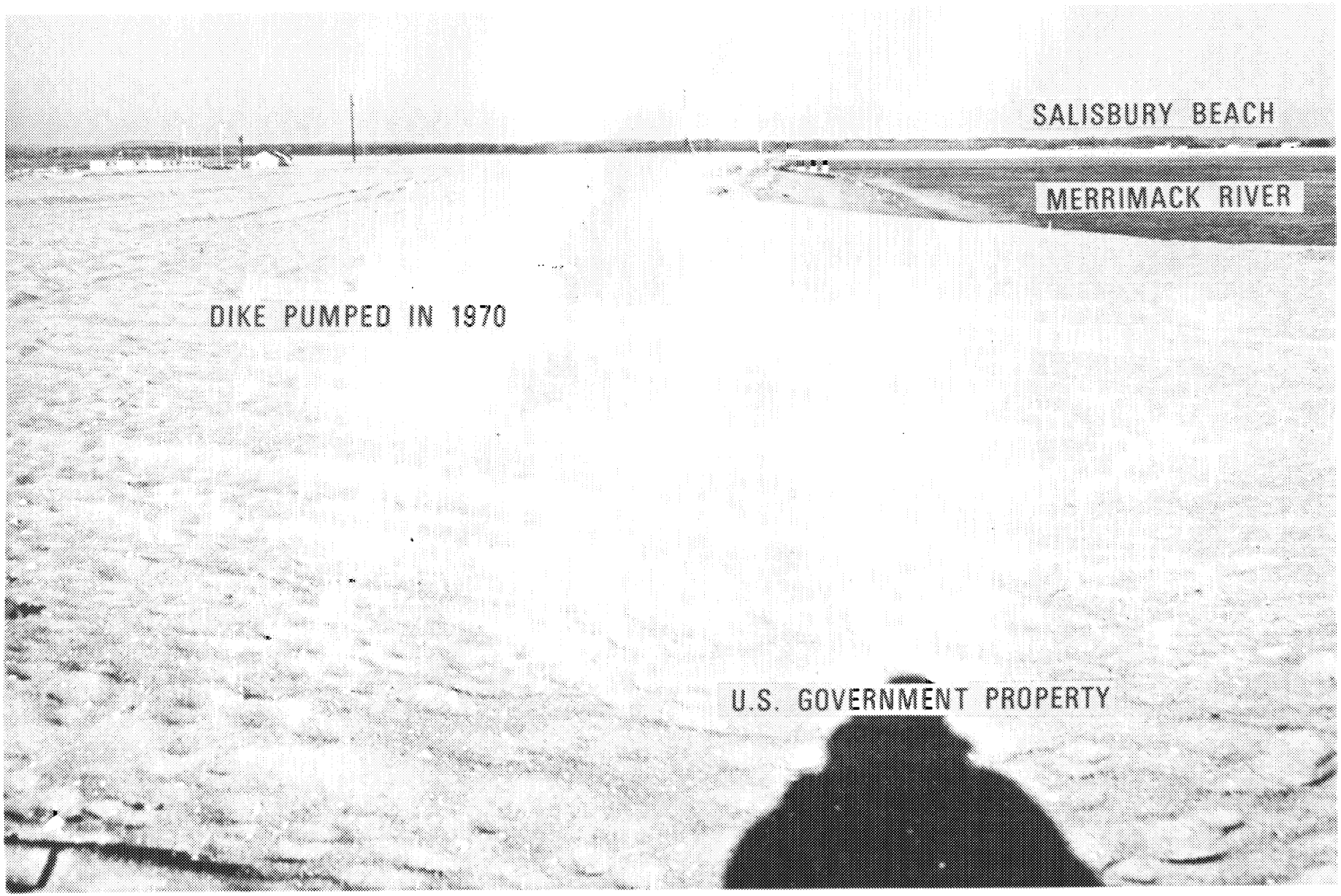


Photo 14. South shore of Merrimack River Dike just after construction November 1970 (see Photo 18 for dike location).

Photo 15. South shore of Merrimack River dike in December 1974. Note deterioration of dike (see Photo 14).

Photo 16. Storm, December 1974, water washed over dike along the south shore of Merrimack River causing flooding of several homes located behind the dike.

postglacial in origin as is demonstrated by the relationship of drumlin formations at the southeast tip of the island. The present configuration of the island has been brought about by a combination of manmade structures, tidal, river, wave, and wind induced processes. (See Appendix D for details).

Littoral Materials

a. Characteristics. Visual inspection, information obtained from the 1952 study and sampling along beach profiles has revealed that the beach material is generally of a medium texture. Dune materials have been found to be made up of a mixture of fine and medium sand. Samples taken at the mouth of the Merrimack River and offshore from the north end of Plum Island indicate that offshore material is coarser than the beach material. Median diameters of the material along the foreshore exceed 0.40 mm but are not greater than 2.0 mm, which is in the range of stable beach building material.

b. Sources. Glacial deposits constitute the major source of beach materials. The drumlins and dunes along the southern shorefront are natural sources of materials and are subjected to severe erosion during storms when wave overtopping of the backshore occurs. Erosion of the unprotected dunes and embankment along the south shore of the mouth of the Merrimack River contribute to the beach building process and to material moving north and south during northeast and southeast storms, as demonstrated by the outer bar at the Merrimack River entrance and offshore along the shorefront.

Littoral Forces

a. Tides. The tides at Plum Island are semidiurnal. The tidal range at the mouth of the Merrimack River at the north end of Plum Island is 8.3 feet and the spring range is 9.5 feet. The mean tidal range at the mouth of the Ipswich River at the south end of Plum Island

is 8.6 feet and the spring range is 9.9 feet. Studies indicate that tides exceed the plane of mean high water by 2 feet or more once a year and by 3 feet or more once every two years. In 1944 and 1959, storm tides of 3.9 feet above mean high water were experienced at Seavey Island in Portsmouth, New Hampshire, which is located about 17 miles north of the study area. On 19 February 1972 a record storm occurred which produced a tide of 4.4 feet above mean high water at Seavey Island.

b. Waves. Wave hindcast studies, based on data obtained at the Penobscot Bay Station, Maine, and the Nauset Beach Station, Cape Cod, Massachusetts (outlined in Beach Erosion Board Technical Memorandum 55), indicate that the maximum waves occur from the east-northeast and east. Over 25 percent of the time the waves are from the east-northeast. Just under 25 percent of the time, the waves are from the east. At least 5 percent of the time, waves approach from the east-southeast. Some small degree of protection from northeast storm waves is afforded by the Isle of Shoals located 15 miles northeast of the Merrimack River entrance. Cape Ann to the south provides some protection from southeast storm waves.

c. Winds. A wind rose completed from a 10 year wind record for Logan Airport, Boston, Massachusetts, shows that the prevailing winds blow offshore from the western quadrants. Winds blowing onshore with significant fetches across the Gulf of Maine and the open ocean from the northeast and southeast quadrants, produce the damaging waves.

d. Currents. An inspection of the 1976 tidal current tables, published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, show that the maximum currents at the Merrimack River entrance do not exceed 2.2 knots. These currents do have an effect on sand movement in and out of the channel entrance and distribution and shaping of the outer bar at the entrance, but, these currents, which are confined to the channel, do not contribute to the erosion along the shorefront south of the river entrance.

e. Storms. A study of records of the United States Weather Bureau at Boston, Massachusetts, shows that the preponderance of gales (winds greater than 39 miles per hour) blow from the northeasterly direction. These storms are usually of long duration extending through several high tides and result in erosion of beach and backshore areas with undermining and damage to or loss of structures and cottages. (See Plate 1 for Wind and Wave Rose Charts.)

Shore History

a. Shoreline Changes. The greatest shoreline changes have occurred at the northern portion of Plum Island at the entrance to the Merrimack River. Historically, these changes occurred prior to construction of the jetties. In 1827, the mouth of the Merrimack River was located about one half mile south of its present position. "The Basin" as it is known today did not exist at that time. The southerly ocean bar migrated northwesterly forming the ocean shorefront and "Basin" during the period from 1827 to 1851. Subsequent to construction of the jetties around the turn of the century, substantial accretion occurred forming the oceanfront shores of the island. Surveys made by the former U.S. Coast and Geodetic Survey (now called National Ocean Survey) and by the Commonwealth of Massachusetts, showed that between 1928 and 1952 a continuous recession occurred along the shore located 3,400 feet to 11,000 feet south of the south jetty. This recession was estimated at 150 feet opposite the south end of "The Basin", 250 feet midway between "The Basin" and the seaward end of the Plum Island Turnpike, 100 feet at the Plum Island Turnpike, 150 feet fronting cottages south of the turnpike which is in the area that is experiencing severe erosion at the present time and 200 feet along 2,000 feet of shore south of the cottages. Surveys which were made in 1968 and 1972 in the area of the turnpike groin structure showed that the shoreline receded an average of 6 feet a year in this area during this time period. (See Appendix E for Details).

b. Prior Corrective Action & Existing Structures. At the time of the beach erosion control study of 1952, there were no significant structures built solely for beach erosion control purposes. The jetties at the entrance to the Merrimack River which were completed in 1914 were built for the purpose of improvement to navigation. In 1969 rehabilitation and improvement work was completed on the south jetty which involved the raising and sealing of the inner end to prevent sand from being washed into the channel from the south shore. In 1953 the Commonwealth of Massachusetts placed about 560,000 cubic yards of sand fill along the beach starting at the Plum Island Turnpike and extending in a northerly direction for a distance of about 3.000 feet. This was done in general accordance with the recommendations made in the 1952 Federal study. The sand fill used was pumped from "The Basin" and contained a large percentage of fines. Between 1954

and 1964, the Commonwealth constructed seven groin structures starting approximately 1700 feet south of the Plum Island Turnpike and extending northerly to the entrance to the Merrimack River a distance of approximately 7700 feet. These groins were constructed to retard the high sand losses along this beach area. In the mid-sixties the state rehabilitated several of these groins and constructed stone revetment along embankments at various locations of the shorefront lying between 1,500 feet and 4,500 feet north of the Plum Island Turnpike.

The U.S. Army Corps of Engineers has also constructed several shore protection projects along the Plum Island shorefront and the south shore of the Merrimack River. Between 9 and 27 February 1969 a series of three winter storms, one of which lasted several days, caused at least 150 feet of erosion at the then U.S. Coast Guard station along the south bank of the Merrimack River to about 450 feet of erosion at the inner bar, located about 2,000 feet to the west. The New England Division, Corps of Engineers constructed a rubble mound erosion protection project fronting the Coast Guard station to protect it and also to keep the Federal south jetty structure from being flanked. A sand dike was also pumped along the south shore of the Merrimack River in conjunction with the rubble mound structure. These protection projects were completed in September 1970. Another near record storm of 19 February 1972 caused serious problems along an 800 foot section of shorefront north of the turnpike groin structure. As a result of this most recent storm the Corps conducted a Section 103 small beach erosion control study resulting in the placement of suitable sand fill to provide a protective and recreational beach as an emergency measure along the seriously eroded sector of the Plum Island shorefront. In addition private property owners have constructed bulkheads or revetment structures from time to time along the eroding embankment fronting their properties. To date, the Corps has expended in access of $4,000,000 on the Island and Newburyport Harbor. Prior to 1959, $565,225 was expended which includes jetty construction and channel improvement. In recent years $1,972,823 was expended on maintenance, $1,415,524 for major rehabilitation work and $156,320 on beach erosion improvements and studies.

Improvements Desired

State and local interests are becoming increasingly more concerned with the seriousness of the erosion problem along the Plum Island shoreline and they are strongly desirous of obtaining a project which will provide protection against further shore erosion, as well as to provide for the recreational salt water bathing needs of the populace in the area.

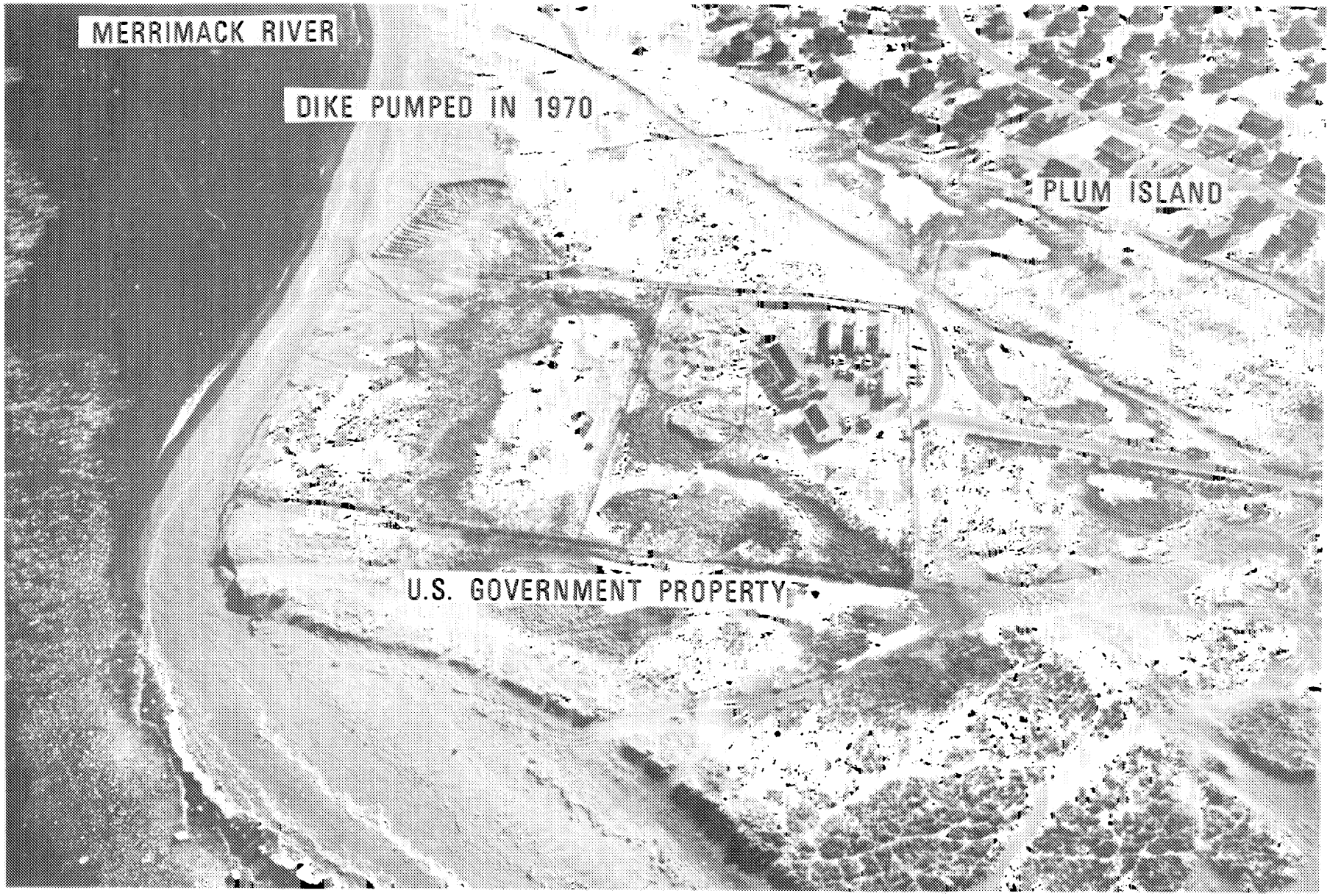


Photo 17. South shore of Merrimack River, U.S. Coast Guard property in the Fall of 1969 just after 2 series of storms that caused extensive damage on Plum Island. (See Photo 18.)

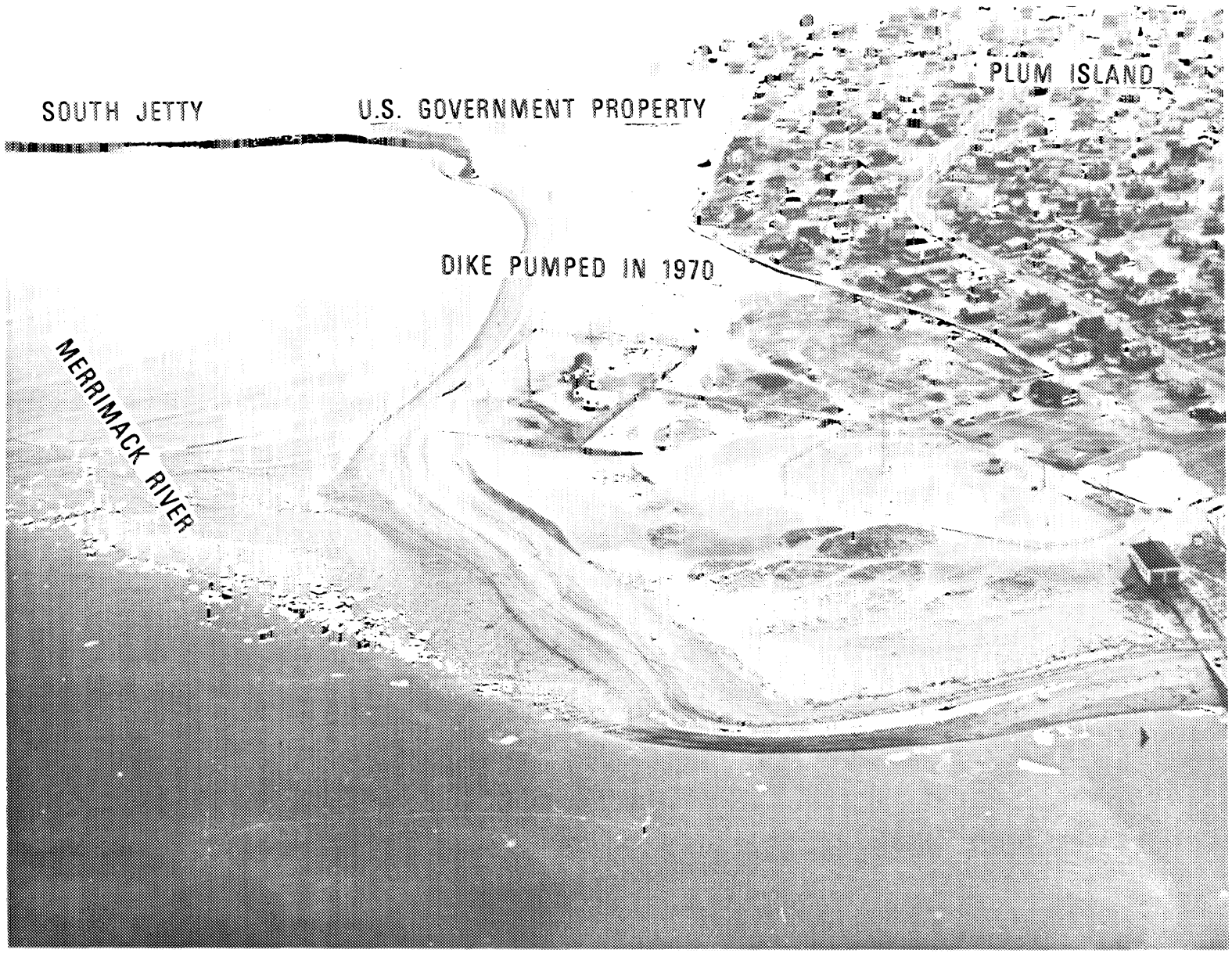


Photo 18. Looking southeast at U.S. Coast Guard property in February 1976. The erosion is continuing, resulting in a loss of valuable backshore dunes. (See Photo 17).

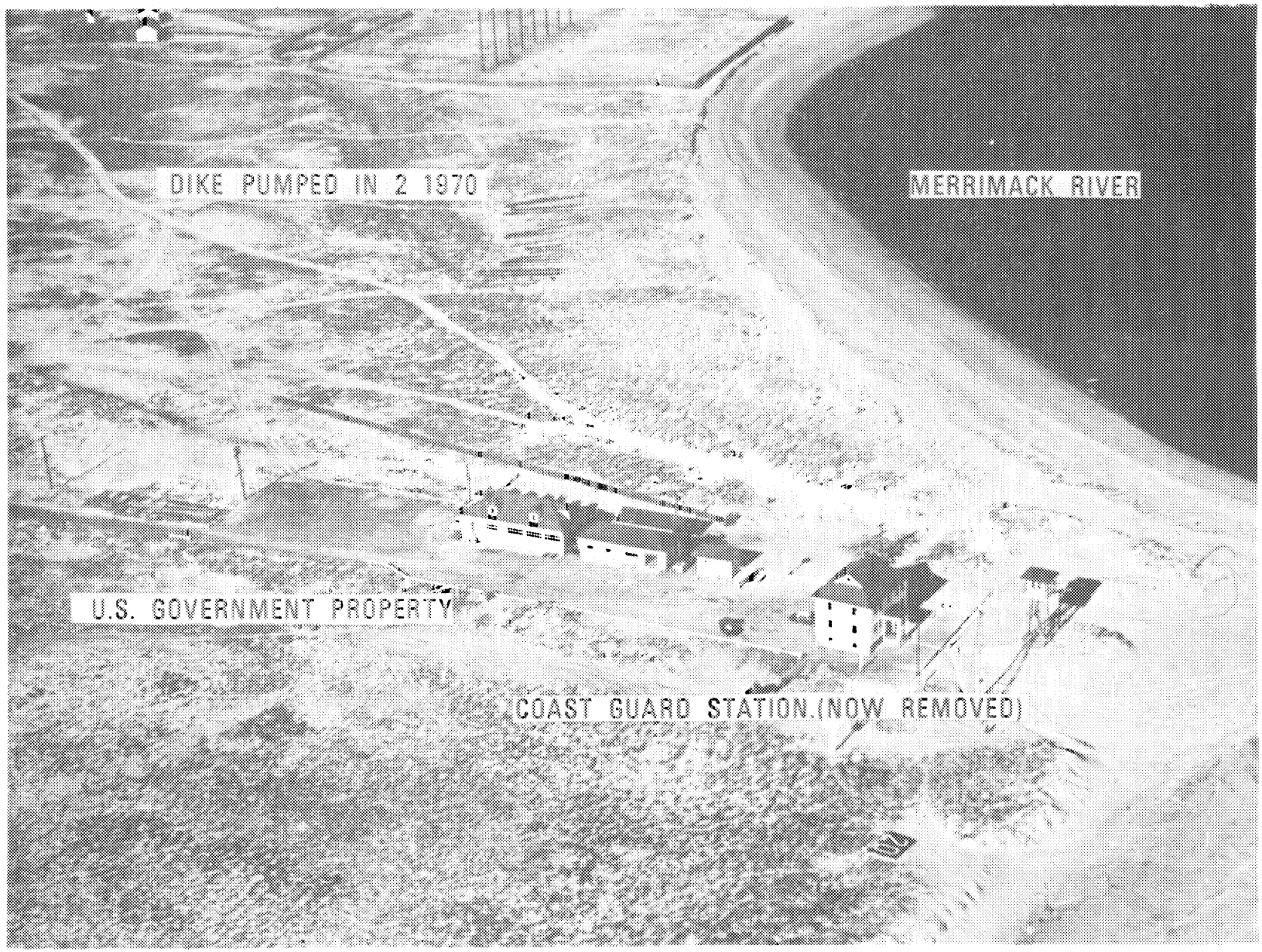


Photo 19. U.S. Government Property and Buildings prior to 1969 storms. Note healthy grass and dune area before a series of storms seriously eroded a large portion of this area (see Photo 20).

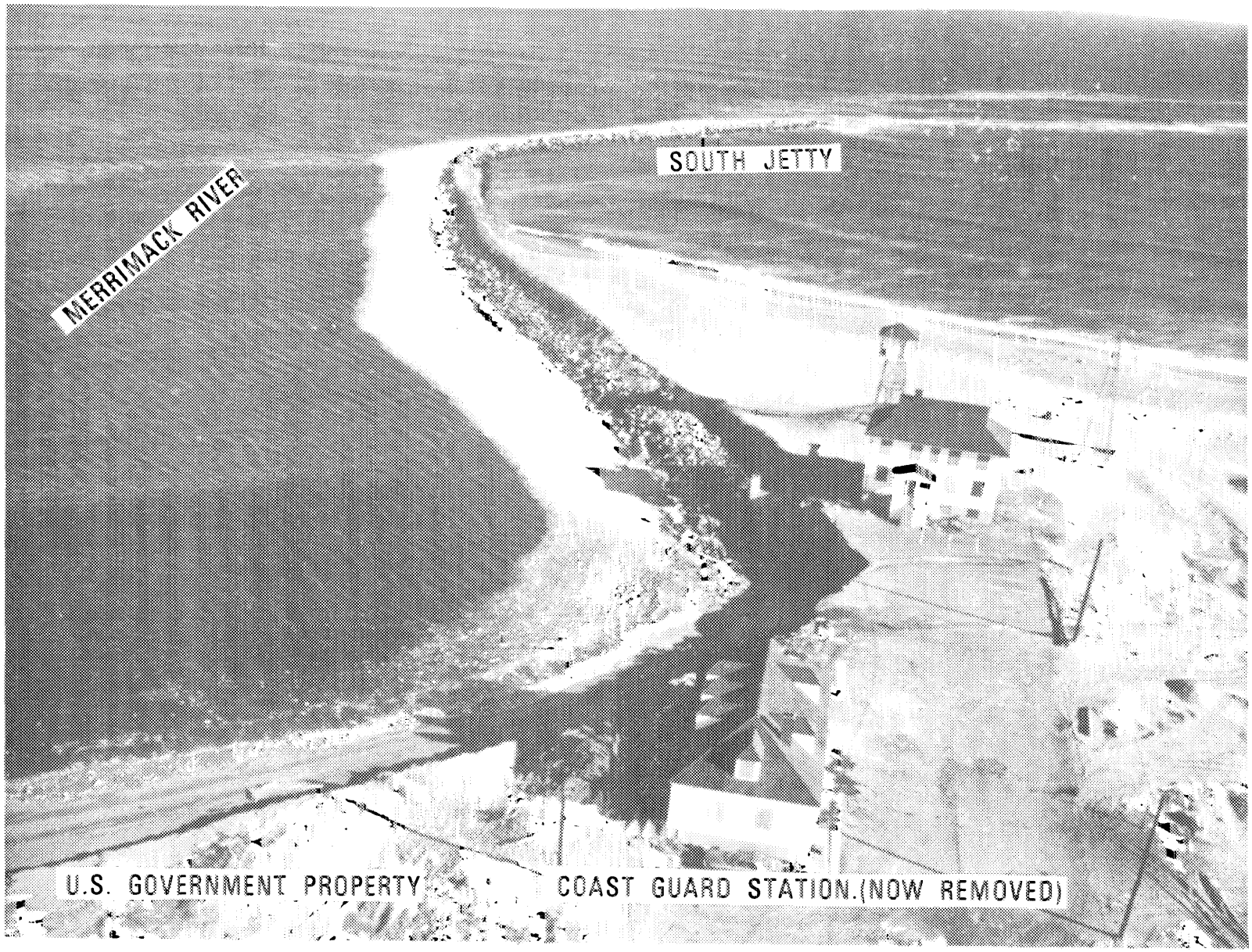


Photo 20. Looking east at U.S. Government property after a series of northeast storms in 1969. (For before photo, see Photo 19).

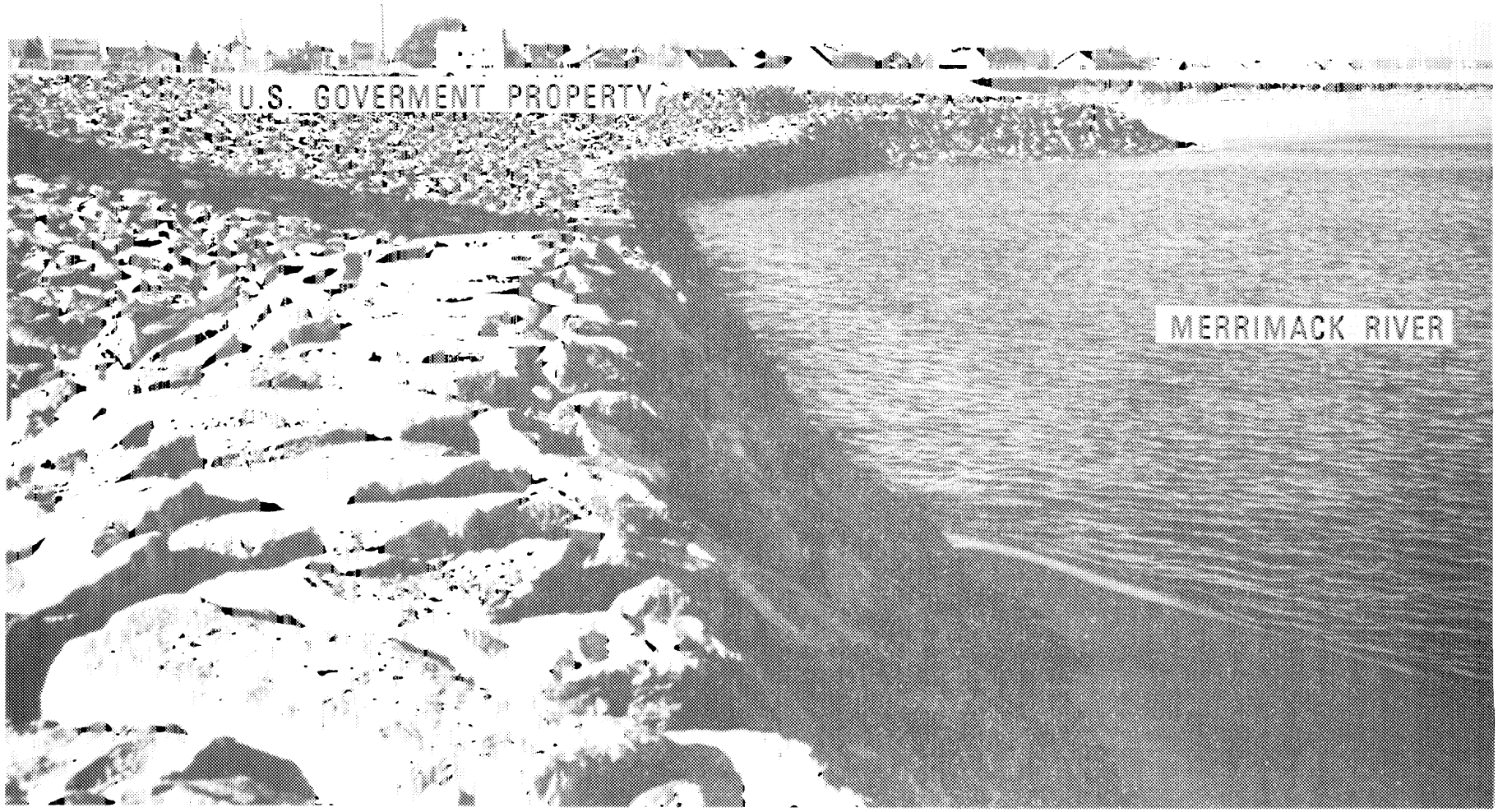


Photo 21. South shore of the Merrimack River revetment constructed by the Corps in 1970 to prevent flanking of the south jetty.

PLAN FORMULATION

The severe erosion and storm damages which have been sustained along the Plum Island shorefront during intense winter storms and tropical hurricanes and the likelihood that the area will continue to experience such destructive events in the future emphasizes the need for developing plans of protection to guard against such future occurrences. In addition the need for salt water bathing areas to provide for the healthful recreation of the populace needs to be addressed. A plan is needed which can insure an adequate degree of protection, addresses the needs for recreational beach area, provide for maximization of net benefits and at the same time minimize possible adverse environmental benefits. All possible alternative plans which may meet these requirements were considered. (See Plate A-1 in Appendix A).

Formulation and Evaluation Criteria

The formulation and evaluation of a plan involves the screening of alternative plans which best meet the appropriate set of formulation and evaluation criteria. Such a set of criteria should include technical, economic, environmental and other pertinent tangible and intangible considerations which lead to the development and selection of a plan which best responds to the problems and needs. The following discussion describes the technical economic, and environmental criteria which were used in plan formulation.

TECHNICAL CRITERIA.

a. Protection should be provided against the storm tide level which would be generated by a severe northeaster which may be expected based on a critical combination of meteorological and hydrological conditions that are reasonably characteristic of the area.

b. Protective works should be designed to minimize the amount of overtopping which may be expected to occur during the design storm.

c. Wave heights used should be those expected to occur in conjunction with the design storm producing the design tidal flood level.

d. For alternative plans which call for the placement of artificial sand fill to form a protective barrier beach, the beach berm should be designed to have sufficient height and width dimensions to dissipate the wave energy produced by the design storm and to resist erosion to the extent that the protective works will not fail during the design storm.

e. A freeboard allowance of at least one foot of height should be assumed for revetment structures and at least two feet for sand dunes.

ECONOMIC CRITERIA.

a. Tangible benefits exceed project costs.

b. Each separate unit of improvement provides benefits at least equal to its cost.

c. The scope of the plan is such as to provide for the maximization of net benefits.

d. There is no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken.

In addition the benefits and costs have been expressed in comparable quantitative economic terms whenever possible. The costs which were developed for the alternative plans were based on a 50-year amortization period and an interest rate of 6-3/8 percent. The annual costs also include the cost of maintenance and sand replacement.

ENVIRONMENTAL AND OTHER CONSIDERATIONS.

a. Public health, safety and social well-being.

b. Provisions for pleasing esthetics and other desirable effects or features.

c. Avoidance of detrimental environmental effects to the maximum extent possible.

Possible Solutions

There are several alternative protection and/or preventative measures which can be employed to provide protection against storm damage and beach erosion along the Plum Island shorefront. These include:

a. Structural Measures.

Offshore Stone Breakwater
Rock Revetment
Nearshore Stone Mound
Stone Groins
Sandfill
Stone Groins and Sandfill

b. Nonstructural Measures.

Zoning Regulations
Building Codes
Sand Dune Use Regulations
Storm Warning System
Emergency Evacuation Plan
Dune Grass Planting
Land Acquisition for Open Space Needs and Buffer Zones
Floodproofing Structures
Sand Fences
Public Education and Awareness Program

The structural measures are discussed in more detail in the following section. The nonstructural measures are touched on briefly in the same section, but a more detailed discussion of the nonstructural measures is found in Appendix C.

Considered Plans

There are a number of protective measures which can be used to provide protection against beach erosion and tidal flooding damage which occurs during severe coastal storms. Six alternative structural measures have been evaluated in this report. The costs associated with these alternative plans are shown in the section entitled Economic Analysis as well as Appendix A.

The initial alternative, Plan I, which was considered involves the construction of an offshore stone breakwater located approximately 1500 feet offshore and parallel to the shoreline along the entire northern limits of the study area. This structure would serve to dissipate the energy of the large waves which impinge on the shoreline during storm conditions and thereby minimize the force with which these broken waves

eventually reach the shoreline. The breakwater would consist of two massive layers of armor cover stone with the middle being filled with small core stone all resting on a base of filter stone. The bottom of the structure would be located at about elevation 12.0 feet below mean low water and the top elevation maintained at about 18.0 feet above mean low water. Maintaining the top of the structure at this elevation will minimize the amount of wave overtopping which will occur except during the most severe storms. The cost associated with a structure of this magnitude is very prohibitive.

Plan II involves the construction of a rock revetment along the limits of the study area at the base of the dunes along the backshore area. This structure would guard against breaching of the backshore dunes with the loss of land and flooding of the area behind the dunes. The bottom of the revetment would be at an average elevation of about 3.0 feet above mean low water and toed in properly to guard against undermining. The top of the revetment would be at elevation 16.0 feet above mean low water so as to minimize the amount of wave runup and overtopping which would occur except during severe northeast winter storms.

Plan III deals with the construction of a nearshore stone mound located about 300 feet seaward of the face of the existing dunes or houses which is employed as a means of providing protection for the study area. The nearshore stone mound would be similar in construction to the offshore stone breakwater. This stone mound would cause the waves impinging on the shore to break on its seaward side thus dissipating this wave energy and preventing beach erosion and flood damage to the backshore area. It appears that there is sufficient beach material landward of this mound so that only a minimal amount of material will be needed to fill in behind this stone mound and most of this material can come from the excavation operations necessary for site preparations. The bottom of the stone mound would be located at approximately 3.0 feet above mean low water and the top would be at an elevation of about 16.0 feet above mean low water. Some overtopping would occur during severe storms.

Plan IV involving the placement of suitable sandfill on the shorefront along the entire limits of the improvement is another method which can be employed to provide protection for the study area. The beach berm should be at sufficient height and width dimensions to dissipate energy from impinging waves and prevent damage to backshore property and structures. The beach berm for the plan

of protection considered would have a width of 100 feet and be set at an elevation of 15.0 feet above mean low water. Provisions would be made to provide for periodic sand nourishment to replace the material which would be lost due to continued erosion.

In Plan V consideration was given to the use of a system of stone groins spaced at 800 feet on centers along the limits of the considered improvement. A system such as this if employed would help to reduce the rate of beach loss and trap the littoral drift moving around in the area. This system would not provide any immediate protection from storms unless it is also supplemented by the placement of suitable sandfill to replace that which has already been lost in critical areas.

The last structural measure Plan VI which was considered was a combination of sandfill and a groin system with the groins spaced at 800 feet on centers similar to that discussed above. Provisions would also have to be made to provide for periodic sand nourishment to replace that which is lost during severe storms. The sandfill would create a beach berm with the same dimensions as the one mentioned above.

All of the above mentioned plans of improvement also would include plans for the stabilization of the south shore of the Merrimack River entrance which will consist of a sand dike with armor stone revetment along the river side of the dike. This protection would be required to extend along about 2,000 feet of river shorefront. (See Appendix A for Costs and Charges; and Plate A-1 for Sections.)

A number of nonstructural regulatory controls can be employed either in conjunction with the structural plans or on their own to reduce beach erosion and storm damages. These controls include zoning regulations, building codes, and restriction of sand dune use. Such regulation can be used to permit wise development in order to prevent excessive damage to both public and private property. Other nonstructural measures which can be employed by the local officials and private individuals include improved storm warning systems, preparation of emergency evacuation plan, dune grass planting program, public education and awareness program, land acquisition for open space needs and buffer zones, floodproofing of structures and implementing a sand fence program. More information regarding these measures are contained in Appendix C.

Effects on the Environment

Considered plans of protection and improvement as discussed in the previous section will have both good and bad impacts on the environment. Continued erosion along the Plum Island shorefront without a protection project will allow the area to continue to change as the physical forces dictate, which in turn will produce both good and bad environmental effects. Some of the impacts the considered plans of protection will have upon the study area are as follows:

Without Improvements

If none of the plans are implemented, the area will flux as the physical forces dictate. Erosion and deposition will continue to change the contour of the shoreline, and the plants and animals will continue to change as the ecosystem changes. There will be no beneficial or adverse effects on benthic organisms. As erosion occurs, they will adapt to changing sediment conditions, with populations existing as at present. The fish communities in the area will be minimally impacted, with populations about as they exist today. However, some communities may be displaced because of material entering the waters. This could cause their food supply to move, and of course the fish would then move. Shore birds and animals may possibly undergo relocation as a result of erosion, but this should be very minor with populations continuing at the present rate. In some areas their food supply may diminish or increase, depending on the extent and condition of the changes of the beach. No major beneficial or adverse impacts will occur if a project is not undertaken with biological, chemical, and physical conditions changing to these dictates of nature.

With Improvements

The impacts of proposed plans will depend largely on the size of the structure used in preventing erosion. All plans will reduce the area that the present biological community can inhabit. The benthic community--certain species within the groups of amphipods, copepods, marine worms and shellfish--will be the most adversely impacted. There will also be a change in the current patterns, and this will effect the feeding ability of those attached organisms dependent upon these currents. However, not all impacts would be adverse.

Almost any surface placed in coastal waters will quickly develop an association of plants, animals and bacteria living on it. The structures used for the projects should develop a luxurious growth of fouling communities that increases each summer and dies back during the winter. The species comprising this growth differ with the area and time of year, but generally the community should be comprised of the following: mussels, barnacles, amphipods, polychaetes, gastropods, crabs and algae. These organisms will attract other forms of life to feed on and hide within this growth.

There will also be some short term impacts during construction, Larger areas than that of just the final structure site will be disturbed. This will mean many organisms will leave the area or die due to these activities. However, these areas should be recolonized shortly after construction activities cease

If a plan of improvement were to materialize in the near future, a comprehensive environmental assessment would be undertaken to determine the impacts on the fish and wildlife presently existing within the ecosystem, and determine possible changes in the community.

ECONOMIC ANALYSIS

This section of the report deals with the economics associated with the various structural plans of improvement which have been discussed in this report. A discussion of the costs, benefits and economic justification of the various plans is included. A more detailed estimate of costs and annual changes are included in Appendix A and

those for benefits are included in Appendix B. Other desirable considerations, such as the nonstructural measures, which have been discussed cannot readily be quantified in dollar values. Cost estimates are based on prevailing 1976 price levels.

General

In order to establish the economic justification of the considered plans a comparison has to be made between the equivalent average annual charges (i.e., interest, amortization, and maintenance costs) with an estimate of the equivalent average annual benefits which would be realized over the 50-year study life which was used. Appropriate values given to costs and benefits at their time of accrual are made comparable by conversion to an equivalent time basis using an appropriate interest rate. A directed rate of 6-3/8 percent applicable to public projects was used in this report.

First Cost

The estimated first cost of the various considered plans of improvement are summarized in Table I below. These estimates include the cost of materials, contingencies, engineering and design work and supervision and administration charges.

TABLE I

IMPROVEMENT COSTS

PLAN NO.	DESCRIPTION	TOTAL FIRST (1) COST
I	Offshore Breakwater	$50,900,000
II	Rock Revetment	7,600,000
III	Nearshore Stone Mound	10,100,000
IV	Sandfill	6,300,000
V	Groins	6,400,000
VI	Sandfill and Groins	8,800,000

(1) All plans include the cost of the proposed improvement for the south shore of the Merrimack River.

Annual Charges

The annual charges are based on the current interest rate of 6-3/8 percent with amortization over a 50 year period. The annual charges shown in Table II include an estimate for maintenance.

TABLE II

ANNUAL CHARGES

PLAN NO.	DESCRIPTION	ANNUAL CHARGES (1)
I	Offshore Breakwater	$3,908,000
II	Rock Revetment	640,200
III	Nearshore Stone Mound	873,700
IV	Sandfill	516,000
V	Groins	490,000
VI	Sandfill and Groins	695,000

(1) All plans include the cost of the proposed improvement for the south shore of the Merrimack River.

Benefits

An estimate of all the benefits expected to result from each of the alternative plans of improvement was made. The primary benefits are based on (1) the reduction in the cost of maintenance of highways, pickup of debris and repair of parking areas frequently required after serious storms, (2) prevention of direct damages by preventing loss of land and (3) the encouragement of recreation by the populace by protection and improvement of the dry beach area. The intangible benefits of increasing the desirability of the beach area and the overall enhancement of the area, particularly in the increased monetary revenues resulting from expanded use of the area and rise in property real estate were not evaluated. Table III below gives a summary of the benefits attributable to the various considered plans of improvements.

TABLE III

SUMMARY OF BENEFITS

PLAN NO.	DESCRIPTION	ANNUAL BENEFITS
I	Offshore Breakwater	$ 125,900
II	Rock Revetment	82,000
III	Nearshore Stone Mound	82,000
IV	Sandfill	145,000
V	Groins	125,900
VI	Sandfill and Groins	145,000

Justification

A summary of the economic analysis of the various considered plans of improvement is shown in Table IV and indicates how the average annual benefits compare with the average annual costs and the resulting ratio of benefits to costs. Only values that can be quantified are included. None of the estimated annual costs and benefits with the resulting ratios of benefits to costs for the considered improvement plans show an economic justification for Federal participation or cost sharing in construction of a beach erosion control improvement project along the Plum Island shoreline.

TABLE IV

SUMMARY OF ECONOMIC ANALYSIS

PLAN NO.	DESCRIPTION	AVERAGE ANNUAL BENEFITS	ANNUAL (1) CHARGES	BENEFIT COST RATIO
I	Offshore Breakwater	$125,900	$3,908,000	0.03
II	Rock Revetment	82,000	640,200	0.13
III	Nearshore Stone Mound	82,000	873,700	0.09
IV	Sandfill	145,000	516,000	0.28
V	Groins	125,900	490,000	0.26
VI	Sandfill and Groins	145,000	695,000	0.21

(1) All plans include the cost of the proposed improvement for the south shore of the Merrimack River.

COORDINATION WITH OTHER AGENCIES AND LOCAL INTERESTS

By its very nature, an investigation to determine the feasibility of providing an improvement and protection measure along the Plum Island shoreline necessitates close coordination between the Corps of Engineers and Federal, State and local agencies and interest groups. On 27 January 1976 a meeting was held in the office of the Secretary of Environmental Affairs for the Commonwealth of Massachusetts. The purpose of the meeting was to inform the representatives of the various Federal, State and local agencies and interest groups in attendance of the status of the erosion problem along the Plum Island shorefront, to explain the way in which this study will be conducted and to ask for their assistance in conducting the study.

In addition Congressman Michael Harrington from the Sixth Congressional District has been closely following the erosion problems which have been plaguing Plum Island in recent years. On 22 March 1976 Congressman Harrington held an informal public meeting in the Newbury Town Hall. The purpose of the meeting was to acquaint the local officials and private property owners with the various types of legislation which may be introduced on their behalf to help alleviate the erosion and flooding problems which have been confronting them. No definitive action has been taken to date as a result of this meeting.

Appendix F contains pertinent correspondence from the various participating agencies and interest groups during the course of the study.

STATEMENT OF FINDINGS

The study has reviewed and evaluated all the pertinent documents and views of interested agencies and the concerned public in the light of the overall public interest. Six possible structural alternative improvement measures were evaluated along with their economic, social and environmental impacts.

None of the considered plans met the economic justification test. The benefit-cost-ratios were found to be below 1.0 which is the minimum acceptable level for Federal participation and cost sharing. Studies indicate that none of the considered plans would have any significant long term adverse impact on the environment and in general they would enhance the social well-being of the people and the property in the area. Due to the unfavorable economic justification Federal participation in cost sharing in any of the considered plans cannot be recommended.

DISCUSSION

The shoreline of Plum Island and along the south bank of the Merrimack River have experienced serious damage at scattered locations in the past. The overall problem is generally one of progressive erosion of the ocean shorefront seaward of the cottages with losses of fronting beach and protective dunes at various locations along the developed northern one-third of the island. This study was undertaken to determine if there is an economically, technically and environmentally feasible plan of improvement and protection which could be developed to help prevent the storm damage and to help provide for the recreational bathing needs in the area.

Six alternative structural measures as well as supporting nonstructural measures were evaluated. None of the structural measures which were evaluated were found to have any economic justification for Federal participation or cost sharing.

Nonstructural measures such as zoning regulations, building codes, sand dune use regulations and others which could be used in conjunction with the structural measures or on their own were discussed. (For additional details see Appendix C.) Nonstructural measures can play an important role in helping to diminish the magnitude of the erosion and other tidal flood damages in the area. However, in and of themselves they will not eliminate the inherent danger or prevent major flood damage along the highly developed area of the Plum Island shorefront. Local governmental officials and private property owners should undertake nonstructural measures such as prohibiting the removal or relocation by man of fill from the beach berm and dunes, erecting sand fences to preserve and build up existing dunes, and restrict access to beaches to protected access routes. The first floor of buildings in areas which are susceptible to storm damage should be floodproofed as necessary. In addition, local interests should have an effective preparedness plan which will provide for appropriate measures to be taken during a storm emergency. The U.S. Army Corps of Engineers, New England Division, has already prepared a document entitled "Coastal Storm Preparedness, Plum Island, Massachusetts," which is intended to serve as the genesis for community action. Copies of this document have already been distributed to local officials. A copy of this document has also been included in Appendix C.

RECOMMENDATIONS

The Division Engineer recommends that no beach erosion control project be adopted by the United States for providing protection against erosion and storm damage along the Plum Island shorefront in light of the lack of economic justification.

The Division Engineer further recommends that improvements considered by local interests be accomplished in accordance with plans and methods discussed in this report. Nonstructural measures as recommended in Appendix C should be implemented as soon as possible. For seriously eroded sections of the shore, problem areas and areas that could develop into problem areas if allowed to continue to erode, consideration should be given to the following:

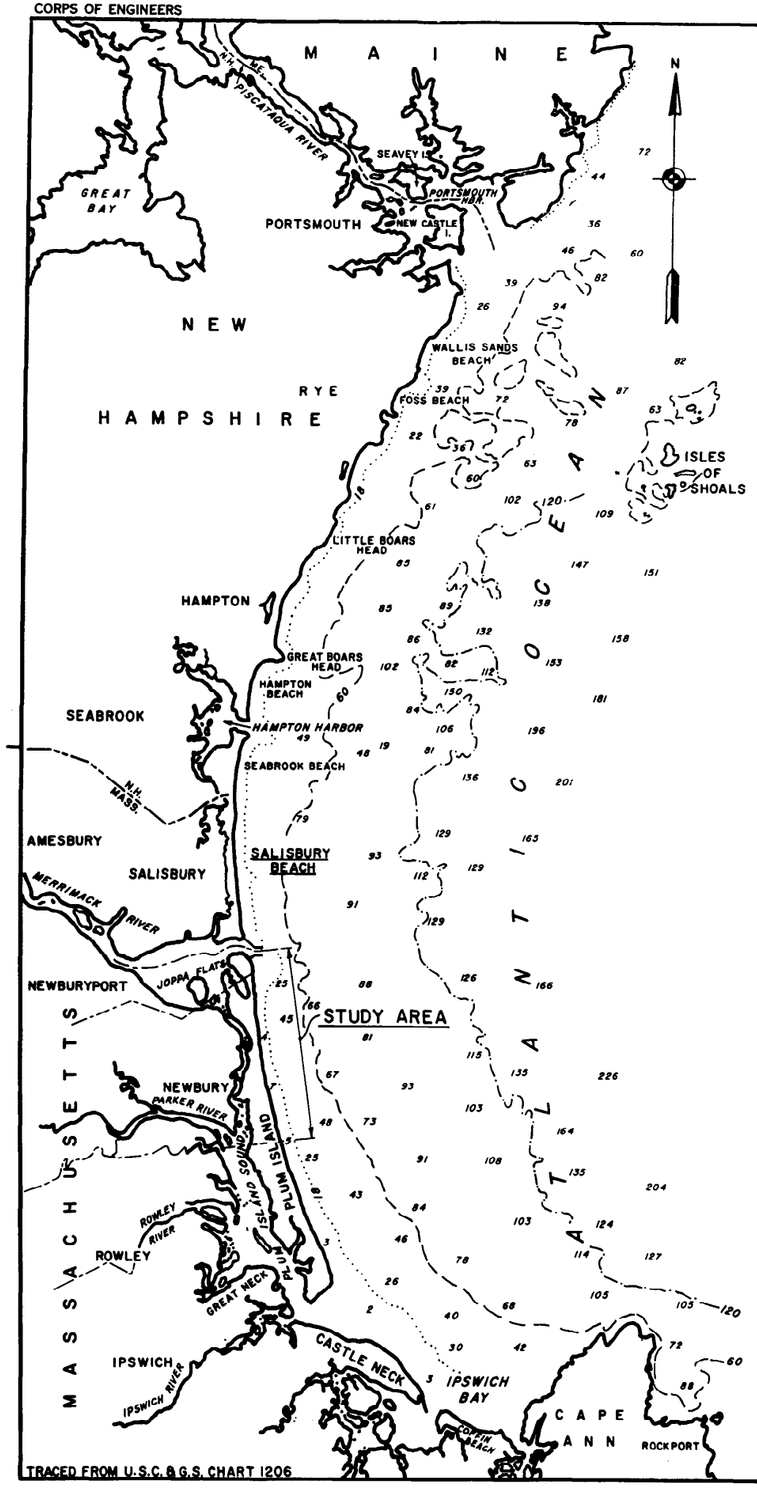
1. Direct placement of suitable sandfill as recommended in Plan IV to widen the beach fronting the cottages and dunes.

2. Periodically nourishing these and other areas as the need arises to maintain a dry beach area to protect the backshore homes and dunes.

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

CORPS OF ENGINEERS

U. S. ARMY



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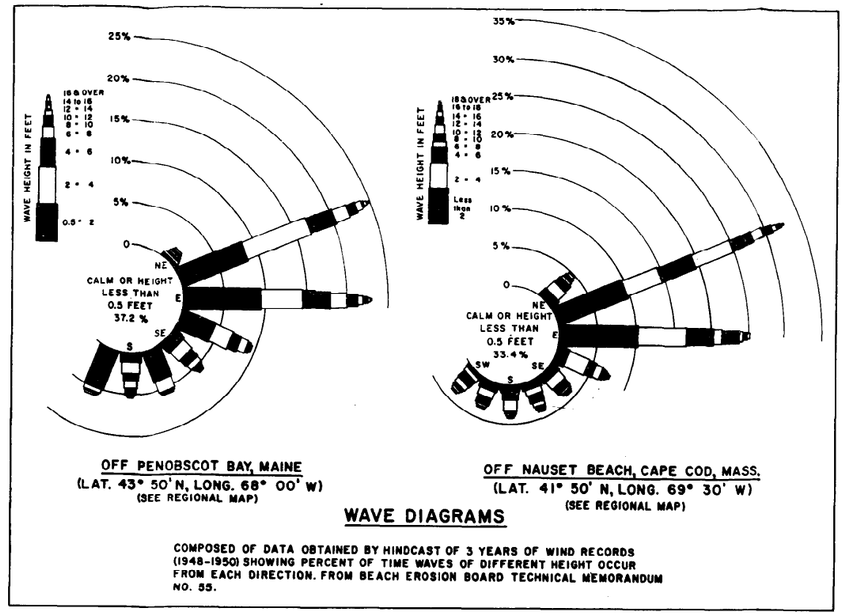
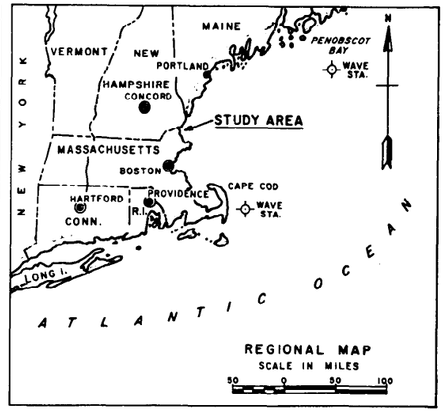


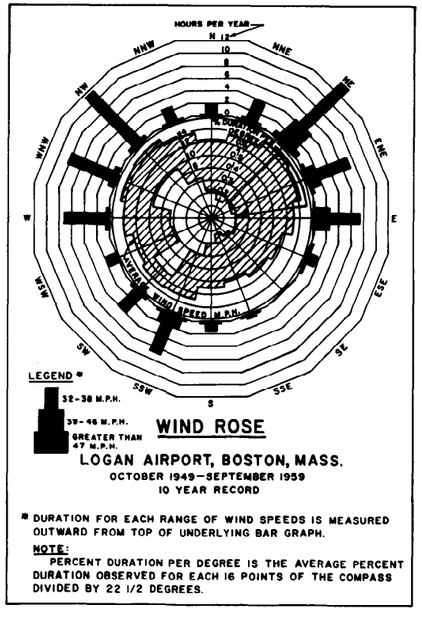
OFF PENOBSCOT BAY, MAINE
(LAT. 43° 50' N, LONG. 68° 00' W)
(SEE REGIONAL MAP)

OFF NAUSET BEACH, CAPE COD, MASS.
(LAT. 41° 50' N, LONG. 69° 30' W)
(SEE REGIONAL MAP)

WAVE DIAGRAMS

COMPOSED OF DATA OBTAINED BY HINDCAST OF 3 YEARS OF WIND RECORDS (1948-1950) SHOWING PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION. FROM BEACH EROSION BOARD TECHNICAL MEMORANDUM NO. 55.





WIND ROSE

LOGAN AIRPORT, BOSTON, MASS.
OCTOBER 1949-SEPTEMBER 1959
10 YEAR RECORD

* DURATION FOR EACH RANGE OF WIND SPEEDS IS MEASURED OUTWARD FROM TOP OF UNDERLYING BAR GRAPH.

NOTE:
PERCENT DURATION PER DEGREE IS THE AVERAGE PERCENT DURATION OBSERVED FOR EACH 16 POINTS OF THE COMPASS DIVIDED BY 22 1/2 DEGREES.

SCALE IN FEET
10000 0 10000 20000

BEACH EROSION CONTROL STUDY

PLUM ISLAND, MASS.

LOCATION MAP

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE NO. 1

APPENDICES

APPENDIX A
PLANS OF CONSIDERED IMPROVEMENT WITH ATTENDANT COSTS AND ANNUAL CHARGES

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

PLANS OF CONSIDERED IMPROVEMENTS

WITH ATTENDANT COSTS AND ANNUAL CHARGES

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LIST OF TABLES

PLATES

PLANS OF CONSIDERED IMPROVEMENTS

WITH ATTENDANT COSTS AND ANNUAL CHARGES

General

The following is a description of each of the considered plans and their first cost and annual charges. The principal features of the plans are shown on Plate A-1. The useful life of the project is taken as fifty years. Costs for the considered plans are calculated along with annual charges based on 1976 price levels. The annual charges reflect the current Federal interest rate of 6-3/8 percent.

Plan I

A stone breakwater located approximately 1,500 feet offshore extending the entire length of the study area, a distance of about 9,300 feet. The top elevation is 18.0 feet above mean low water.

First Cost		
Stone 1,600,000 Tons		$32,500,000
Contingencies		6,500,000
	Sub-Total	39,000,000
Engineering & Design		4,000,000
	Sub-Total	43,000,000
Supervision & Administration		4,000,000
Total First Cost		$47,000,000
Federal Share of Cost (50%)		$23,500,000
Non-Federal Share of Cost (50%)		$23,500,000
Federal and Non-Federal Annual Charges		
Federal Investment		
Interest and Amortization (0.06680 x $23,500,000)		$ 1,570,000
Total Federal Annual Charges		$ 1,570,000

Non-Federal Investment	
Interest and Amortization	
(0.06680 x $23,500,000)	$1,570,000
Breakwater Maintenance	
(16,000 Tons @ $30.00)	480,000
Total Non-Federal Annual Charges	$2,050,000
Plan I: Total Annual Charges	$3,620,000

Plan II

Rock Revetment located along the base of the dunes, with an average bottom elevation of 3 feet above mean low water and a top elevation of 16.0 feet above mean low water and extending for about 9,3000 feet along the shoreline.

First Cost	
Stone 142,000 Tons	$2,600,000
Contingencies	500,000
Sub-Total	$3,100,000
Engineering & Design	300,000
Sub-Total	$3,400,000
Supervision & Administration	300,000
Total First Cost	$3,700,000
Federal Share of Cost (50%)	$1,850,000
Non-Federal Share of Cost (50%)	$1,850,000
Federal and Non-Federal Annual Charges	
Federal Investment	
Interest and Amortization	
(0.06680 x $1,850,000)	$ 123,600
Total Federal Annual Charges	$ 123,600
Non-Federal Investment	
Interest and Amortization	
(0.06680 x $1,850,000)	123,600
Revetment Maintenance	
(3,000 Tons @ $35.00)	105,600
Plan II: Total Annual Charges	$ 352,200

Plan III

Nearshore stone mound located about 300 feet seaward of the face of the existing dunes and cottages, constructed to an average depth of 3 feet above mean low water with a top elevation of 16 feet above mean low water for a distance of 9,300 feet.

First Cost:		
Stone 253,500 Tons		$4,000,000
Sand 100,000 C.Y.		300,000
Contingencies		860,000
	Sub-Total	$5,160,000
Engineering & Design		500,000
	Sub-Total	$5,660,000
Supervision & Administration		500,000
Total First Cost		$6,160,000
Federal Share of Cost (50%)		$3,080,000
Non-Federal Share of Cost (50%)		$3,080,000
Federal and Non-Federal Annual Charges		
Federal Investment		
Interest and Amortization (0.06680 x $3,080,000)		205,700
Total Federal Annual Charges		205,700
Non-Federal Investment		
Interest and Amortization (0.06680 x $3,080,000)		205,700
Stone Maintenance (5,000 Tons @ $35.00)		175,000
Total Non-Federal Charges		$ 380,700
Plan III: Total Annual Charges		$ 586,400

Plan IV

Placement of suitable sandfill along about 9,300 feet of shorefront. The sandfill would provide for a 100 foot wide berm at elevation 15.0 feet above mean low water and a dry beach width of about 200 feet above the mean high water line. The beach will slope seaward on a 15 horizontal to one vertical slope.

First Cost		
Sandfill 500,000 C.Y.		$1,700,000
Contingencies		300,000
	Sub-Total	$2,000,000
Engineering & Design		200,000
	Sub-Total	$2,200,000
Supervision & Administration		200,000
Total First Cost		$2,400,000
Federal Share of Cost (50%)		$1,200,000
Non-Federal Share of Cost (50%)		$1,200,000
Federal and Non-Federal Annual Charges		
Federal Investment		
Interest and Amortization (0.06680 x $1,200,000)		80,250
Periodic Nourishment (7,500 cy @ $4.50)		33,750
Total Federal Annual Charges		$ 114,000
Non-Federal Investment		
Interest and Amortization (0.06680 x $1,200,000)		80,250
Periodic Nourishment (7,500 cy @ $4.50)		33,750
Total Non-Federal Annual Charges		$ 114,000
Plan IV: Total Annual Charges		$ 228,000

Plan V

A system of 11 groins spaced 800 feet apart along the entire length of the considered improvement.

First Cost		
Groins 92,500 Tons		$1,750,000
Contingencies		350,000
	Sub-Total	$2,100,000
Engineering & Design		200,000
	Sub-Total	$2,300,000
Supervision & Administration		200,000
Total First Cost		$2,500,000

Federal Share of Cost (50%)	$1,250,000
Non-Federal Share of Cost (50%)	$1,250,000

Federal and Non-Federal Annual Charges

Federal Investment	
Interest and Amortization (0.06680 x $1,250,000)	83,500
Total Federal Investment	$ 83,500
Non-Federal Investment	
Interest and Amortization (0.06680 x $1,250,000)	83,500
Groin Nourishment (1,000 Tons @ $35.00)	35,000
Total Non-Federal Investment	$ 118,500
Plan V: Total Annual Charges	$ 202,000

Plan VI

A combination of sandfill from Plan IV and the groin system from Plan V.

First Cost			
Sandfill	500,000 C.Y.		$1,700,000
Stone	92,500 Tons		1,750,000
		Sub-Total	$3,450,000
Contingencies			650,000
		Sub-Total	$4,100,000
Engineering & Design			400,000
		Sub-Total	$4,500,000
Supervision & Administration			400,000
Total First Cost			$4,900,000
Federal Share of Cost (50%)			$2,450,000
Non-Federal Share of Cost (50%)			$2,450,000

Federal and Non-Federal Annual Charges

Federal Investment	
Interest and Amortization (0.06680 x $2,450,000)	$ 163,500
Periodic Nourishment (5,000 cy @ $4.50)	22,500
Total Federal Investment	$ 186,000
Non-Federal Investment	
Interest and Amortization (0.06680 x $2,450,000)	$ 163,500
Periodic Nourishment (5,000 cy @ $4.50)	22,500
Groin Maintenance (1,000 Tons @ 35.00)	35,000
Total Non-Federal Investment	$ 221,000
Plan VI: Total Annual Charges	$ 407,000

Stabilization of the South Shore of the Merrimack River entrance: This consists of improving about 2,000 feet of shorefront by the direct placement of a sand dike with armor stone revetment along the river side of the dike.

First Cost		
Sandfill	150,000 C.Y.	$ 611,000
Stone	83,600 Tons	2,089,000
	Sub-Total	$2,700,000
Contingencies		550,000
	Sub-Total	$3,250,000
Engineering and Design		320,000
	Sub-Total	$3,580,000
Supervision and Administration		320,000
Total First Cost		$3,900,000
Federal Share of Cost (50%)		$1,950,000
Non-Federal Share of Cost (50%)		$1,950,000

Federal and Non-Federal Annual Charges

Federal Investment	
Interest and Amortization (0.06680 x $1,950,000)	$ 130,000
Total Federal Investment	$ 130,000

Non-Federal Investment	
Interest and Amortization (0.06680 x $1,950,000)	$ 130,000
Revetment Maintenance (800 Tons @ 35.00)	28,000
Total Non-Federal Investment	$ 158,000
Total Annual Charges	$ 228,000

Table A-I gives a summary of the first cost of the six plans of improvement shown on the previous pages, as well as, the first cost of providing an improvement along the south shore of the Merrimack River. A discussion of the benefits and a benefit cost analysis is presented in Appendix B.

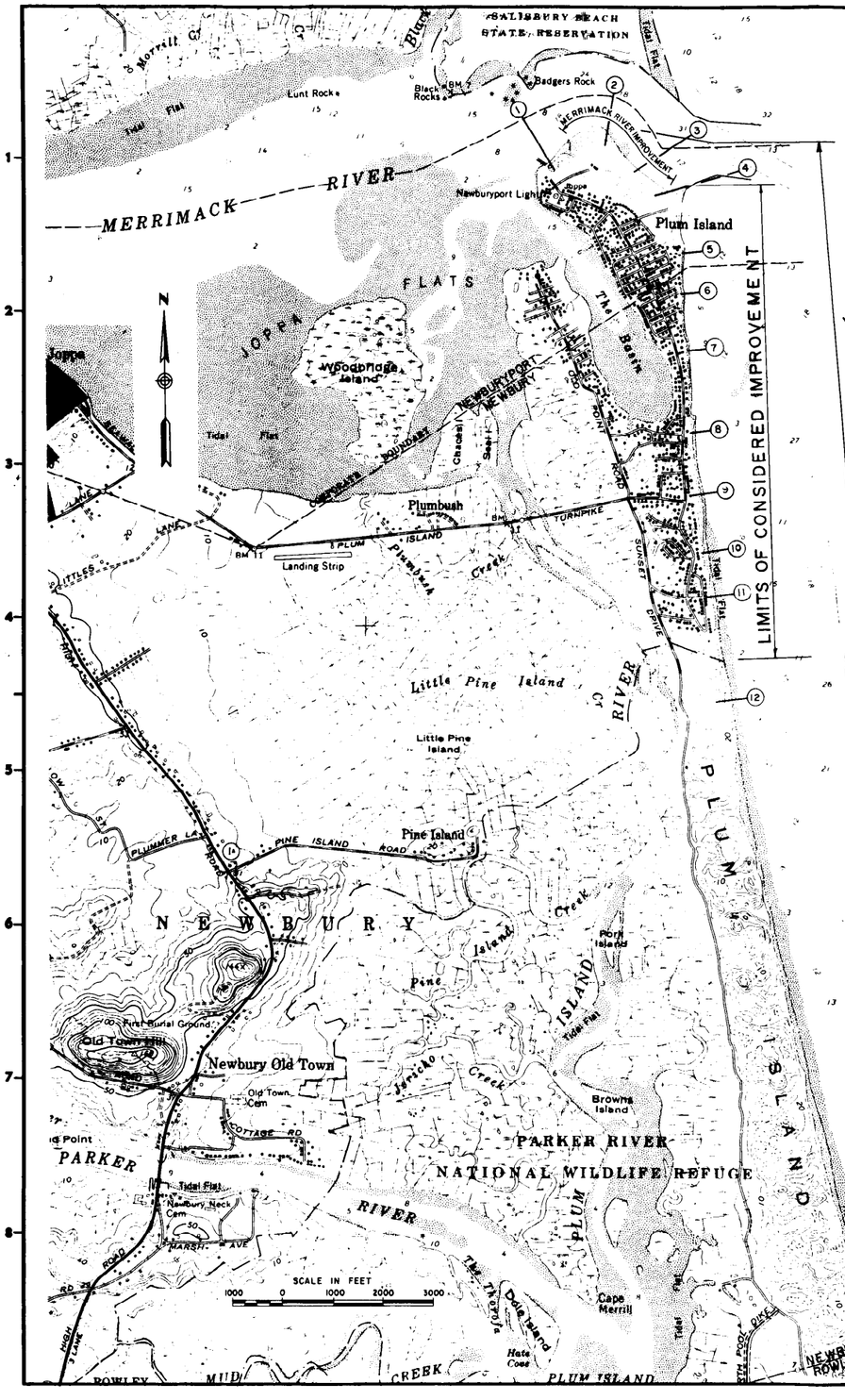
TABLE A-I

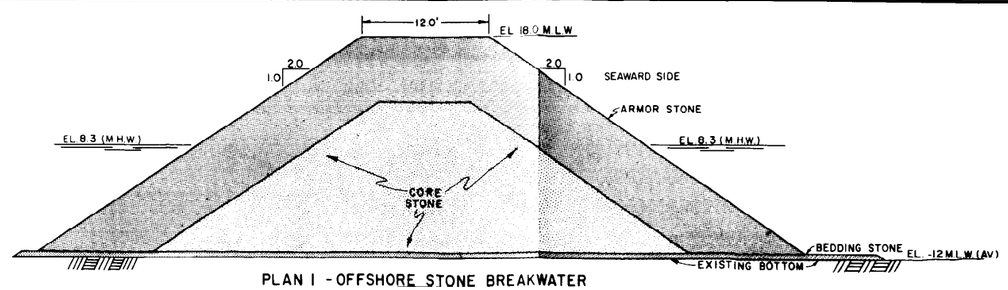
SUMMARY OF FIRST COST

PLAN NO.	TYPE OF PROTECTION	FIRST COST		TOTAL COST
		OCEANFRONT	MERRIMACK RIVER PROTECTION (1)	
I	Offshore Breakwater	$47,000,000	$3,900,000	$50,900,000
II	Rock Revetment	3,700,000	3,900,000	7,600,000
III	Nearshore Stone Mound	6,160,000	3,900,000	10,060,000
IV	Sandfill	2,400,000	3,900,000	6,300,000
V	Groins	2,500,000	3,900,000	6,400,000
VI	Sandfill and Groins	4,900,000	3,900,000	8,800,000

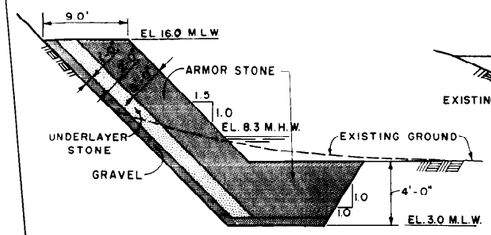
(1) All plans include the proposed improvement for the south shore of the Merrimack River.

U. S ARMY

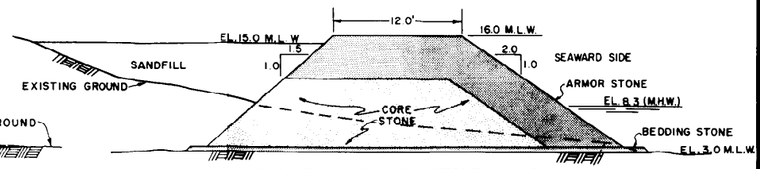




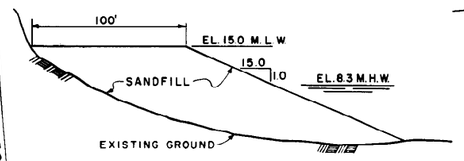
PLAN 1 - OFFSHORE STONE BREAKWATER



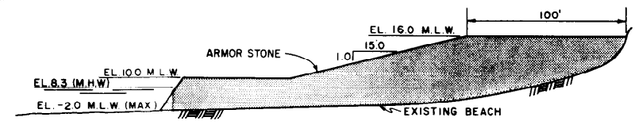
PLAN 2 - ROCK REVETMENT



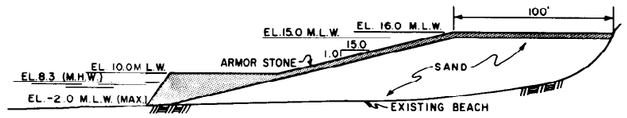
PLAN 3 - NEARSHORE STONE MOUND



PLAN 4 - PLACED SANDFILL ONLY



PLAN 5 - STONE GROINS



PLAN 6 - STONE GROINS AND PLACED SANDFILL

LEGEND

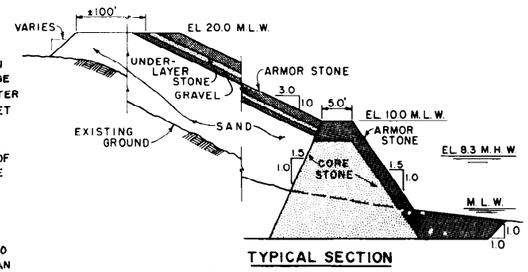
(10) INDICATES SURVEY PROFILES

TYPICAL SECTIONS
CONSIDERED PLANS OF IMPROVEMENT

NOT TO SCALE

NOTES

1. TOPOGRAPHY FROM U.S. GEOLOGICAL SURVEY MAP 1966, CONTOUR INTERVAL 10 FEET, DATUM IS MEAN SEA LEVEL.
2. PLAN 1 — OFFSHORE STONE BREAKWATER APPROXIMATELY 1500 FEET OFFSHORE ALONG THE LIMITS OF IMPROVEMENT. TOP ELEVATION IS ABOUT 18.0 FEET ABOVE MEAN LOW WATER, WITH AN AVERAGE BOTTOM ELEVATION OF ABOUT 12.0 FEET BELOW MEAN LOW WATER
3. PLAN 2 — ROCK REVETMENT AT AN AVERAGE BOTTOM ELEVATION OF 3.0 FEET ABOVE MEAN LOW WATER AND A TOP ELEVATION OF 16.0 FEET ABOVE MEAN LOW WATER ALONG THE BASE OF THE DUNES.
4. PLAN 3 — NEARSHORE STONE MOUND LOCATED ABOUT 300 FEET SEAWARD OF THE FACE OF DUNES OR HOUSES. CONSTRUCTED TO AN AVERAGE DEPTH OF THREE FEET ABOVE MEAN LOW WATER AND A TOP ELEVATION OF 16 FEET ABOVE MEAN LOW WATER ALONG THE LIMITS OF THE IMPROVEMENT.
5. PLAN 4 — PLACEMENT OF SUITABLE SANDFILL ALONG THE SHOREFRONT ALONG THE LIMITS OF IMPROVEMENT. THIS WILL PROVIDE A 100 FOOT LEVEL BEACH BERM AT ELEVATION 15.0 FEET ABOVE MEAN LOW WATER AND A DRY BEACH WIDTH ABOVE THE MEAN HIGH WATER LINE OF ABOUT 200 FEET.
6. PLAN 5 — A SYSTEM OF STONE GROINS SPACED 800 FEET ON CENTER ALONG THE LIMITS OF IMPROVEMENT.
7. PLAN 6 — SANDFILL AND GROINS, A SYSTEM OF STONE GROINS SPACED 800 FEET ON CENTER ALONG THE LIMITS OF IMPROVEMENT, INCLUDING PLACEMENT OF SUITABLE SANDFILL BETWEEN THE GROINS.
8. ALL PLANS INCLUDE STABILIZATION OF THE SOUTH SHORE OF THE MERRIMACK RIVER ENTRANCE WHICH WILL CONSIST OF A SAND DIKE WITH ARMOR STONE REVETMENT ALONG THE RIVER SIDE OF THE DIKE. THIS PROTECTION EXTENDS FOR ABOUT 2,000 FEET OF RIVER SHOREFRONT.



TYPICAL SECTION
SOUTH SHORE OF MERRIMACK RIVER
NOT TO SCALE

BEACH EROSION CONTROL STUDY
PLUM ISLAND, MASS.
PLANS OF CONSIDERED IMPROVEMENT

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE A-1

APPENDIX B
ESTIMATES OF BENEFITS, SOCIAL AND ECONOMIC EFFECT ASSESSMENT FROM IMPROVEMENT

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

ESTIMATES OF BENEFITS, SOCIAL AND ECONOMIC EFFECTS ASSESSMENT FROM IMPROVEMENT

SECTION 1 ESTIMATES OF BENEFITS

SECTION 2 SOCIAL AND ECONOMIC EFFECTS ASSESSMENT

SECTION 1.

ESTIMATES OF BENEFITS.

ESTIMATES OF BENEFITS

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SECTION 1

ESTIMATES OF BENEFITS

General

The primary benefits attributed to the improvement and computed herein are based on (1) the reduction in the cost of maintenance of highways, pick-up of debris, and repair of parking areas frequently required after serious storms; (2) prevention of direct damages by preventing loss of land; and (3) the encouragement of recreation by the populace by protection and improvement of the dry beach area. The intangible benefits of increasing the desirability of the beach area and the overall enhancement of the area, particularly in the increased monetary revenues resulting from expanded use of the area and rise in property real estate, has not been evaluated. The United States does own land in the project area involved. The Coast Guard Station which was formerly located on this land has been closed for several years. Therefore, no Federal benefit will result from the plans considered. Recreational benefits are evaluated as general and local public benefits. Benefits derived from the prevention of loss of land are evaluated as private and public benefits.

Reduction of Maintenance and Repair Costs

Damages prevented at Plum Island are in the form of reduction in costs of clearance of debris and wreckage, repair or replacement of roads, streets and highway facilities, and drainage facilities required after severe storms. Available figures from the Massachusetts Civil Defense Agency, indicate annual emergency expenditures of approximately $11,000 over a three year period from 1973 to 1975.

Prevention of Loss of Land

The proposed improvement will prevent loss of land, both public and private, which has been occurring for many years. The entire residential sector of the island would be protected by the proposed project. Several homes have already been either lost or moved back closer to Northern and Southern Boulevard. The threat of serious breaching which would endanger low-lying lots further inland has existed. In March of this year, one home south of Plum Island Turnpike Road fell

into the water; three other adjacent homes were threatened and will soon be moved. Local sources indicate that the threat of breaching along with interior flooding now occurs during severe storms and abnormally high tides.

At the end of 50 years without the project, it is estimated that approximately 100 feet of land behind today's MHW Line (assumed erosion rate of two feet per year) will be lost. Under the assumption that no government agency will protect Northern Boulevard from flooding, it is estimated that the maximum potential loss of land could be as high as 1,780,000 square feet. The anticipated average annual loss of property and structures is valued at $2.50 per square foot.* This can be broken down into two elements. The first element is the non-recurring loss of land of 750,000 square feet or average annual loss of land of 15,000 square feet per year. Based on $2.50 per square foot, it is estimated that erosion would cause annual losses of $37,500 to ocean front property.

The second element consists of damages to the backshore property on the landward side of Northern and Southern Boulevards. These damages can be estimated by two different methods. The first method estimates that 92 homes in the area would be subject to annual storm damages of approximately $200 per unit. The annual damages determined by this method could be as high as $18,400. The second method is based on the assumption that the anticipated annual damages will seriously reduce the economic value of any home. In other words, the property subject to such damage potential would have minimal market value. Following this assumption, 20,600 square foot of backshore land would receive storm damages on an average annual basis. Valued at $2.50 per square foot, total economic losses could amount to $51,500. With the typical structure bearing 80% of the total value, the economic loss would amount to $41,200.

Also along the Merrimack River frontage, damages are anticipated to the backshore property. The previous methodology is used to estimate these damages. Ten homes in the area subject to annual storm damages could receive approximately $200 of damages per unit. The annual estimate could be as much as $2,000. Using the second method, 120,000 square feet or an annual average of 2,400 square feet of property could

*Several sources were used to determine this value. (1) Local officials and real estate agents in both communities were interviewed. (2) A survey was made of (a) property sales at market prices for 1974 and 1975 and (b) market value for a random selection of property.

be damaged. Valued at $2.50 per square foot annaul damages are estimated to be $6,000. The annual economic loss, at 80% of market value is $4,800. Therefore, the total backshore damage, along both the ocean side and the river, is $20,400 for method one and $46,000 for method two.

Thus the total loss resulting from land erosion and storm damage, calculated under two different methods, is as follows:

METHOD 1		METHOD 2
$37,500	Element One	$37,500
20,400	Element Two	46,000
$57,900		$83,500

The average of these two methods is $71,000 and this figure will be used in this study. However, a second scenario for damage determination exists. It can be assumed that the State or local government will protect Northern and Southern Boulevard if the erosion problem continues. This would prevent the Island from a potential breach in the basin area. Without the project, in this case, $37,500 of potential losses could occur.

Recreation

Plum Island Beach, located on Massachusetts recreation oriented "North Shore", caters basically to local Essex County residents and the overflow from the areas more popular and better equipped private, municpal, state and Federal swimming facilities. In essence, it is the lack of public use facilities, very limited parking facilities, and lack of service establishments which prevent this beach from becoming one of the most popular areas on the "North Shore" of Boston.

Looking at the supply of swimming facilities in Eastern Massachusetts, the Atlantic Ocean is the major water resource. Although the coastal strip is richly endowed with hundreds of miles of irregular and indented coastline which provides many sheltered and sandy beaches, the increasingly intensive use of these water areas has created problems.

In general, the major problems are a lack of public access and polluted waters which have limited the use of many water areas. At Plum Island, the particular problem of erosion and extremely restricted parking facilities has contributed to the under-utilization of this resource.

Coinciding with the above mentioned problems the shrinking supply, expanding population, and rising personal income coupled with general trends toward more leisure time and greater mobility, have increased the pressure on the recreational demand-supply relationship. The population of Essex County alone expanded from 568,800 persons in 1960 to 637,900 in 1970, or an increase of 12 percent.

In preparation of the "Massachusetts Outdoor Recreation Plan," dated February 1976, the State Department of Environmental Management researched the recent demand-supply relationship of swimming facilities for the Eastern Massachusetts Planning Region. In 1970, the population of Massachusetts, one of the most urban states in the nation, was 5,706,776. Of this, 3,787,384 persons or 66 percent were concentrated in the Eastern Massachusetts Planning Region which is centered on the city of Boston. In terms of annual activity days, (1) swimming facilities showed a shortage of 10.9 percent in 1975. In the year 2,000, demand is projected to exceed beach capacity by 20 percent. The state planners projected current supply at a rate corresponding to current program levels and determined that unmet swimming needs would greatly increase in the future.

The Eastern Massachusetts Region's average population density of 1,650 persons per square mile is more than twice the average for the State. The availability of general recreation facilities on a per capita basis is worse in this region than in the State as a whole. Thus the implication is strong that existing public and private programs providing swimming will have to be greatly increased if these needs are to be met. Documentation of the demand-supply relationship for Plum Island Beach in terms of "with-and-without" the proposed project is set forth in the following paragraphs.

Recreation Demand

The beach space demand is determined from a composite of the demand from summer residents, transient tourists, day-trippers, and guests who visit friends on the island. The demand for beach space for each of these components is set forth below.

(1)
An activity is defined as one person participating in a given activity for part or all of one day.

Beach Space Demand of Summer Residents

The permanent summer population of Plum Island consists of the permanent year-round resident population and the local seasonal increase. The seasonal increase consists primarily of summer vacationing families in which the head of the household commutes daily or weekly to his normal place of employment and also of summer residents who derive their income from tourist services at Plum Island. In absolute numbers, the 1975 population in the Newbury portion of Plum Island increased from a permanent year-round level of 1,300 persons to an estimated 5,000 persons during the summer. In the Newburyport portion of the island, the 1970 population increased from a permanent year-round level of 539 persons to an estimated 1,250 persons during the summer.

Of the estimated 4,400 person seasonal increase, 60% (2,640 people) are estimated to be seasonal residents who own their cottages, and 40% (1,760 people) are transient tourists who rent cottages for a one or two week vacation. Thus, a total of 4,480 persons are perennial seasonal residents. Considering the composite of permanent summer residents, it is estimated that average beach attendance on peak days constitute 75% of this population. Thus, 2,860 summer residents desire beach space on peak use days. On weekdays, however, it is estimated that beach demand for this group amounts to approximately 40% of peak day demand or 1,200 persons.

Beach Space Demand of Transient Tourists

As indicated above, approximately 1,760 tourists on any given day visit Plum Island during the summer months and rent a cottage for generally one or two weeks. Since they primarily visit this area for the purpose of swimming it is estimated that 75% (1,000 people)* desire beach space on both peak days and weekdays in the project area.

Beach Space Demand of Day-Trippers

Estimating the number of day-trippers to Plum Island proves difficult, for there is a lack of statistical data for the entire island. The only reliable data is from the Parker River Wildlife Refuge which estimates an annual attendance of approximately 375,000 persons. It

*Adjusted for 300 people who use only the Basin to swim.

should be noted that the reservation must often be closed to the public on peak days at around 10:30 a.m. due to a lack of parking spaces. Local sources indicate that traffic increases heavily when this occurs as the overflow filters out to the other part of the island where our study area lies.

One simple method for estimating day-trippers is to determine the available parking facilities in the immediate project area and their occupancy rates. Field investigations indicate that there are 950 spaces for public parking facilities. Eight hundred spaces exist on the Newbury part of the island and 150 spaces on the Newburyport sector. Parking is limited to one side of Northern Boulevard, with a total of 150 spaces, there is no off-street parking because all other roads on the island are private rights-of-way. Only one public lot exists in Newburyport.

Local sources indicate that on a peak day, all 950 spaces are continuously filled with a heavy turnover, estimated to average two automobiles per space. On weekdays, about 40% (380) of the spaces are estimated to be continuously occupied. Assuming an average of 4.5 people per car, it is estimated that 8,550 day-trippers desire beach space on peak days and 3,400 on weekdays. To these totals must be added "drop-offs" from the mainland which are estimated to be 500 persons on peak days and 200 on weekdays. Total day-trippers account for 9,050 people on a peak day and 3,600 on a weekday. Finally, guests of people who own or rent cottages on the island account for an estimated 4,050 peak day users and 1,000 weekday users.

Total Beach Space Demand

A summary of the composite of summer residents, transient tourists, day-trippers and guests demand for beach space is as follows:

TOTAL BEACH DEMAND

	Attendance	
	Peak Day	Weekday
Permanent summer	2900*	1200
Transient tourists	1000	1000
Day-trippers	9050	3600
Guests of people who have cottages	4050	1000
TOTAL	17,000	6,800

*Rounded from 2860

For 1975, as developed in the above analysis, the weekday attendance is about 40% of the peak day. For later years, this ratio is estimated to increase in order to reflect greater leisure time and higher income trends. The increase is as follows:

	Ratio of Weekday to Peak Day
1975	40%
2000	50%
2025	58%

Utilizing these ratios, the potential beach demand is determined to be the following:*

	Beach Demand (Fig. 1)		
	1975	2000	2025
Peak Day	17,000	22,207	27,781
Weekday	6,800	11,108	16,112

Recreational Supply

Erosion is a natural and prevailing condition that exists throughout Plum Island. At present (and this will vary from one short time span to another), there are approximately 1,810,000 square feet of dry beach area above the mean high tide line. If the erosion is allowed to continue unchecked, by the year 2020, it is estimated that erosion will have reduced the available dry beach area above the mean high tide to zero. In terms of capacity, based on a beach use area of 75 square feet per bather and a turnover rate of two, the project area today is able to accommodate about 48,266 persons per day. In fifty years, this will be reduced to zero.

Two of the six proposed plans would provide an additional dry beach area of 990,000 square feet for an increased capacity of 26,400 persons. Adding to the existing capactiy, a total of 74,666 persons would be provided beach space under "with-the-project" conditions. Thus, these proposed plans would satisfy both weekday and peak day demand of today.

*Boston is the largest and closest Standard Metropolitan Statistical Area (SMSA) to Plum Island. OBERS rates of population growth for the Boston SMSA from 1970 to 2020 is applied to Plum Island's beach demand.

Recreational Benefits

The recreation benefits for Plum Island are predicated on a bathing season extending from mid-June to the 1st of September. Allowing for 25% inclement weather, there are an estimated 18 peak use bathing days and 40 weekdays of bathing use. A beach use area of 75 square feet per bather, with a turnover of two, is used as the maximum degree of usage. A reasonable per capita recreational value of a fully developed, public-use beach, with an adequate parking area and sufficient sanitary and bathhouse facilities with no over-crowding is $1.25 per visit. For an incompletely developed public-use beach such as Plum Island, having minimum basic facilities, but where the general public will always have free and easy access to the beach, an average value of $0.85 is considered appropriate.

Annual recreation benefits are determined under "with-and-without" the project conditions and are shown below:

	Peak	Week
Gross	$302,684	$322,185
Existing	275,458	286,349
Net	$ 27,226	$ 35,836

Total Project Benefits	Ocean Front	Merrimack River	Total
Reduction of Maintenance and Repair Costs	$ 11,000	---	$ 11,000
Prevention of loss of land*	67,600	$3,400	71,000
Recreation	63,000	---	$ 63,000
TOTAL	$141,600	$3,400	145,000

In addition to the foregoing primary benefits, there will be very strong intangible (non-quantifiable) benefits. Two of the more important ones would be the elimination of the potential hazard to the health and safety of local residents, and the prevention of loss of both employment and school days.

Maximization of Net Benefits

The six proposed plans are shown in three categories. Plans II and III are a non-beach, shore protection plan. Plans IV and VI include additional beach space as well as backshore protection. Plans I and V

*No protection to N&S Boulevard without the Corps project.

provide some protection (the actual amount is uncertain and 75% is a conservative estimate) to the existing beach space as well as backshore protection.

Schedule A includes the stabilization of the south shore of the Merrimack River entrance in each of the six proposed plans. Schedule B excludes this stabilization plan.

FINAL FIGURES

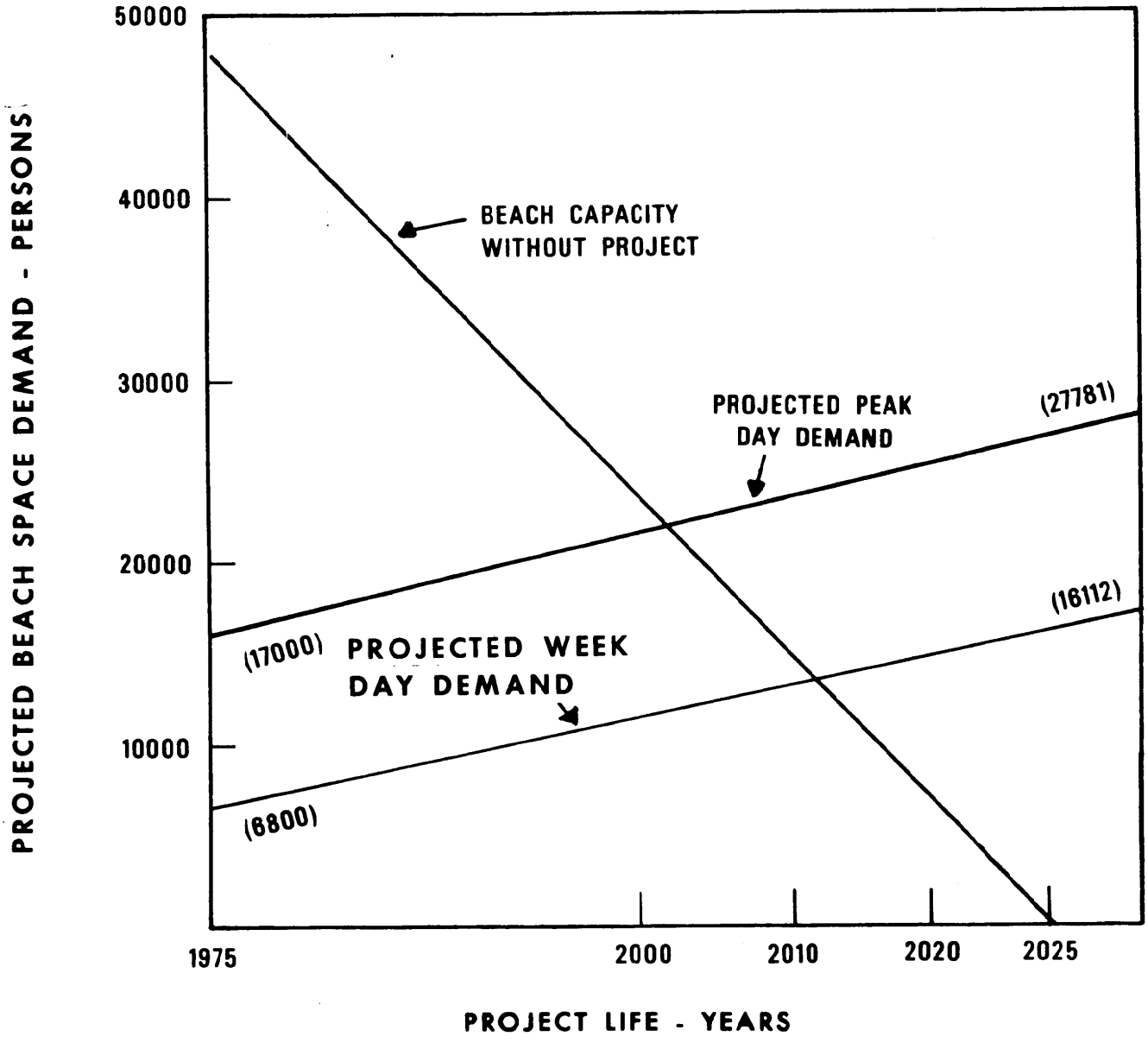
Schedule A*

Plan	Annual Cost	Annual Benefits	BCR	Excess Costs over Benefits
I	$3,908,000	$125,000	0.03	$3,782,100
II	640,200	82,000	0.13	558,200
III	873,700	82,000	0.09	791,700
IV	516,000	145,000	0.28	371,000
V	490,000	125,900	0.26	364,100
VI	695,000	145,000	0.21	550,000

Schedule B

I	$3,620,000	$122,500	0.03	$3,497,500
II	352,200	78,600	0.22	273,600
III	586,400	78,600	0.13	507,800
IV	228,000	141,600	0.62	86,400
V	202,000	122,500	0.61	79,500
VI	407,000	141,600	0.35	265,400

*An interest rate of 6-3/8% is used



BEACH EROSION CONTROL STUDY
PLUM ISLAND
BEACH POTENTIAL DEMAND / SUPPLY

Appendix B
Figure 1

SECTION 2

SOCIAL AND ECONOMIC EFFECTS ASSESSMENT

SOCIAL AND ECONOMIC EFFECTS ASSESSMENT

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SECTION 2

SOCIAL AND ECONOMIC EFFECTS ASSESSMENT

General

To adequately assess alternatives to the solution of a problem, it is helpful to identify the social, economic, and environmental effects. This aids decision makers in selecting a plan which will yield the greatest beneficial effects while minimizing adverse effects. The social and economic impacts of the alternative plans have been identified in this appendix.

This section of the appendix actually consists of 3 parts. The first part describes the base condition of the study area in terms of its geography, economy, population, and its potential growth and development. The second part identifies the problem and establishes the without project condition which exists if no plan is adopted. The third part briefly describes the various alternatives and discusses the potential impacts with the adoption of a plan. A display of the social and economic impacts is included.

Geography

Plum Island is located partly in the city of Newburyport and the towns of Newbury, Rowley, and Ipswich, approximately 40 miles north of Boston in the northeast corner of Massachusetts. The shoreline is about 8 miles in length and consists of a sandy coastal barrier bar largely covered with dunes along its southern two-thirds.

The northern one-third of the island, within the limits of the city of Newburyport, and the town of Newbury, has residential and commercial development. This end of the island has 1161 summer and year round cottages, one church, a limited number of commercial establishments, and U.S. Coast Guard property. The southern portion of the island within the limits of Newbury and Rowley, consists of the Parker River Wildlife Sancturay under the jurisdiction of the U.S. Fish and Wildlife Service. A State park is located at the southern tip of the island within the limits of the town of Ipswich. Since the Plum Island Turnpike is the only road linking the mainland to the island, beach going traffic rapidly builds up by mid-morning on peak summer days. Much of this traffic goes into the wildlife refuge.

Population

The 1975 population for the city of Newburyport was 16,300; and for the town of Newbury, it was 4,223. Their permanent year round population for the developed section at the north end of Plum Island is approximately 1,300 for the Newbury portion and 539 for Newburyport. These 1839 people represent 9.0% of the total population of Newbury and Newburyport. During the summer season the population increases to approximately 6,200. In recent years there has been a definite trend in converting summer residences to year-round residences. Year-round population has increased from 100 in 1950 to 1839 at the present time. The total summer population has experienced minimal growth during the 1970's because of restrictions placed on new construction and the limited number of available lots.

Growth

Neither the city of Newburyport nor the town of Newbury is encouraging growth on Plum Island. In the past, the size of the average lot was 70' x 70'. Over 90% of residential lots are of this size. Today, it is required that lots must be at least 100' x 100' in order for each property to safely maintain a water supply and septic tank. Construction has been prohibited since most available lots do not meet this requirement unless two or more contiguous lots have been purchased.

The congestion of the area not only has put extra demands on enforcement of health regulations, but also has placed extra stress on adequate fire protection. During a busy summer day, it is very difficult for fire equipment to pass through the area quickly. Many homes converted to winter residences have poor electrical wiring, creating an additional hazard. To compound all this, the fire department must transport water onto the island since there is no available supply for fire protection.

Although future growth is limited, the island is attractive to potential buyers. A real estate agent on Plum Island indicated that the volume of his business has tripled over the past five years. He feels that the price range, attractive climate, proximity to Boston, and moratorium on construction are the major factors for investment on Plum Island. Even though the island has been recently zoned 100% residential, the "grandfather" clause permits already existing commercial establishments to stay in business.

Economics

Very little economic activity takes place on Plum Island. There is no manufacturing. Commercial activity consists of restaurants, food shops, fishing tackle shops and two boat rental businesses. The year round residents, therefore work either in the city of Newburyport or the town of Newbury, or travel farther distances to communities within the Boston Standard Metropolitan Statistical Area (SMSA) and surrounding labor market areas of Lawrence and Lowell. Table I compares the personal incomes of residents in Newbury and Newburyport to Essex County and the State of Massachusetts.

TABLE 1

Personal Income (1970, U. S. Census)

	Median Family Income	Per Capita Income
Newbury	$11,800	$3,663
Newburyport	9,992	2,953
Essex County	9,141	3,490
Massachusetts	10,835	3,425

A measure of accumulated personal income is wealth and one measure of wealth is the value of property. Although the selling price of a few homes would exceed $75,000, the median price ranges from $24,000 to $30,000. Typical homes have recently sold for as little as $15,000 and as much as $40,000. The value of property has increased very sharply over the past few years.

Recreation

Looking at the supply of swimming facilities in eastern Massachusetts the Atlantic Ocean is the major water resource. Although the coastal strip is richly endowed with hundreds of miles of irregular and indented coastline which provides many sheltered and sandy beaches, the increasingly intensive use of these water areas has created problems. In general, the major problems are a lack of public access and polluted waters which have limited the use of many water areas. At Plum Island, the particular problems of erosion and extremely restricted parking facilities have contributed to the under utilization of this resource. Coinciding with the above mentioned problems the shrinking

supply, expanding population and rising personal income coupled with general trends toward more leisure time and greater mobility, have increased the pressure on the recreational demand-supply relationship. The population of Essex County alone expanded from 568,800 persons in 1960 to 637,900 in 1970. an increase of 12 percent.

In preparation of the "Massachusetts Outdoor Recreation Plan Report" dated February 1976, the Department of Environmental Management researched the recent demand-supply relationship of swimming facilities for the Eastern Massachusetts Planning Region. The report determined that in 1970, the population of Massachusetts, one of the most urban States in the nation, was 5,706,776. Of this 3,787,384 persons or 66 percent were concentrated in the Eastern Massachusetts Planning Region which is centered on the city of Boston. In terms of annual activity days, swimming facilities showed a shortage of 10.9 percent in 1975.* In the year 2000, demand is projected to exceed capacity by 20 percent. The state planners projected current supply at a rate corresponding to current program levels and determined that unmet swimming needs would greatly increase in the future.

The Eastern Massachusetts Region's average population density of 1,650 persons per square mile is more than twice the average of the state. The availability of general recreation facilities on a per capita basis is worse in this region than in the state as a whole. Thus the implication is strong that existing public and private programs providing swimming will have to be greatly increased if these needs are to be met.

The Problem

The shoreline of Plum Island is subject to erosion of the beach and sand dunes, especially during storms. Erosion during major storms has caused cottages to topple into the sea, serious reduction of lot sizes, and total loss of some oceanfront lots. Loss of land and the potential for serious damage has necessitated moving several cottages landward.

Shorefront erosion has been occurring at Plum Island since the early 1880's when the mouth of the Merrimack River was located one-half mile south of its present position. Jetties constructed at the turn of the century have stabilized the entrance of the river at its present location. However, since 1928, recession of the shoreline has continued as a result of severe storms and subsequent wave attack.

*An activity day is defined as one person participating in a given activity for part or all of one day.

A near record storm on 19 February 1972 destroyed a wide fronting beach, backlying dunes, and one cottage, with serious damage to at least two others. With continued erosion at this area, a breakthrough by the ocean would have been possible, resulting in the destruction of an additional 11 houses, loss of protective dunes to the north, and flooding of at least 30 houses and commercial establishments. A small beach erosion control study conducted by the Corps under the Small Projects Authority, was found to be economically feasible resulting in the placement of sandfill to provide protection and stabilize the beach. The location of erosion has been unpredictable; residents, whose property has been experiencing severe erosion at this time, can easily recall a spacious beach area while other areas were rapidly eroding. Now some of these eroding areas have considerable accretion.

At present the Plum Island shorefront has two erosion problem areas. One area is the south shore of the Merrimack River which is owned by the U.S. Coast Guard; and the other is a section of the beach approximately 1,000 feet long, south of the turnpike groin structure. This section of shorefront has eroded badly during the past winter with damages to at least four cottages, one of which fell into the ocean. Although these homes have been moved back, they are still in danger of continuing erosion. At present, no problem exists along the greater part of the island south of the residential area. This portion, making up approximately 2/3 of the island, is a wildlife sanctuary and does not have any development close to the shore.

Objective of Study

The primary objective of the study is to determine the most practical and economical solution to the continuing erosion problem on Plum Island. The study will also provide alternative methods of nearshore protection that can be adopted by the residents to help reduce the rate of erosion.

Without Project Condition

Without a project, the shoreline will continue its general trend of erosion. Although some oceanfront properties have already been

moved landward on their present lots as far as possible, they will continue to be in danger and eventually topple into the ocean unless relocated on inland lots. Oceanfront and inland properties both north and south of the Plum Island Turnpike Road will be subject to continuous flooding. Areas south of the turnpike road are especially susceptible to flooding and erosion. Oceanfront structures could be destroyed, leaving low lying backshore areas subject to flooding. Continued recesssion of the shore could result in breaching of the island and isolation of its northern end. This would isolate about 450 cottages and a number of business establishments. Furthermore, the continued erosion will greatly limit the available beach space not only for residents but also for day-trippers and summer transients.

At the end of 50 years without a project, it is estimated that approximately 100 feet of land behind today's MHW line (assumed erosion rate of two feet per year) will be lost. Under the assumption that no government agency will protect Northern Boulevard from flooding, it is estimated that the maximum potential loss of land could be as high as 1,780,000 square feet.

The anticipated average annual loss of property and structures is valued at $2.50 per square foot.* This can be broken down into two elements. The first element is the nonrecurring loss of land of 750,000 square feet or average annual loss of land of 15,000 square feet per year. Based on $2.50 per square foot, it is estimated that erosion could cause annual losses of $37,500 to shorefront property.

The second element consists of damages to the backshore property on both sides of Northern and Southern Boulevards. These damages can be estimated by two different methods. The first method estimates that 92 homes in the area subject to annual storm damages would receive approximately $200 of damages per unit. The annual damages determined by this method could be as high as $18,400. The second method is based on the assumption that the anticipated annual damages will seriously reduce the economic value of any home. In other words, the property subject to such damage potential would have minimal market value. Following this assumption, 20,600 square feet of backshore land would receive storm damages on an average annual basis. Valued at $2.50 per square foot, total economic losses could amount to $51,500 with the typical structure bearing 80% of the total value, the economic loss would amount to $41,200.

*Several sources were used to determine this value. (1) Local officials and real estate agents in both communities were interviewed. (2) A survey was made of (a) property sales at market prices for 1974 and 1975 and (b) market value for a random selection of property.

Also along the Merrimack River frontage, damages are anticipated to the backshore property. The previous methodology is used to estimate these damages. Ten homes in the area subject to annual storm damages would receive approximately $200 of damages per unit. The annual estimate could be as much as $2,000. Using the second method, 120,000 square feet or an annual average of 2,400 square feet of property could be damaged. Valued at $2.50 per square foot, annual damages are estimated to be $6,000. The annual economic loss, at 80% of the market value is $4,800. Therefore, the total backshore damage, along both the oceanside plus the river, is $20,400 for method one and $46,000 for method two. Thus the total loss resulting from land erosion and storm damage calculated under the two different methods is as follows:

Method 1	Method 2
$37,500	$37,500
20,400	46,000
$57,900	$83,500

The average of these two methods is $71,000 and this figure will be used in this study.

However, a second scenario for damage determination exists. It can be assumed that the state or local government will protect Northern and Southern Boulevard if the erosion problem continues. This would prevent the island from a potential breach in the basin area. Without the project, in this case $37,500 of potential losses would occur.

Responsibility

In the past, the responsibility of property defense against the erosion and flooding has been that of private property owners. These ocean property owners have constructed bulkheads and revetments or dumped sandfill along the eroding embankment fronting their properties. Without a project, the property owners would still depend on their own resources to protect their lands and cottages (See Appendix C).

The Corps of Engineers undertook and completed a beach erosion control improvement in March 1973. With a threat of a breakthrough caused by a near record storm in February and September 1972, sandfill

was placed along 800 feet of backshore at the end of the Plum Island Turnpike. Whether future action of this type can or will be taken by the Corps cannot be determined at this time. Factors such as land ownership, public access and economic, social and environmental justification must be taken into consideration before any further improvements can be implemented on the island.

Formulation of Alternatives

No Action

The "no action" alternative would result in the continued erratic erosion of the Plum Island shoreline. There would be continued storm damage to property in the area. Because erosion is unpredictable, it is difficult to project where damages would most likely occur. The without project condition discussed above indicates the result of the no action alternative.

Permanent Evacuation

This alternative involves the removal of inhabitants, residences and other buildings from the developed portion of Plum Island. New locations for these homes would be sought in Newbury and Newburyport. However, this alternative will meet strong opposition and cannot be viewed as a realistic solution.

Relocation

This alternative involves moving homes in critical areas to vacant town lots where danger does not exist. The residents themselves have indicated resistance to relocation. Many of the properties along the oceanfront are summer residences and are most appealing because of their ocean exposure. These people are not seeking the security of a year-round residence so would prefer to "stick-it-out" and hope a change in wave action would result in accretion rather than continuing erosion.

Local officials in Newbury indicate that there has been some conscientious consideration of this alternative and that the town is holding land that could be suitable for relocation. The overall feeling from local souces in both the city of Newburyport and the town of Newbury is that resistance to this type of action is so strong that it cannot be discussed as a realistic solution. It is estimated that approximately 37 houses in the Newbury portion and 25 homes in the Newburyport section would have to be relocated over the next 50 years if they are to be protected from storm damages.

Structural Alternatives

Six structural alternatives are being considered for beach erosion control at Plum Island. All six alternatives will provide protection against storm damages and property losses. Two alternatives, the offshore stone breakwater and the stone groins will protect the property as well as approximately 75% of the existing beach space. This beach space will immediately be lost with construction of a nearshore stone mound. With a rock revetment, however, the existing beach in front of the structure will continue to undergo the past pattern of erratic erosion with the potential for complete loss. The remaining two alternatives the sandfill and sandfill with groins will create additional beach area in addition to protecting the existing beach and property. Each alternative includes an additional structure to stabilize the south shore of the Merrimack River entrance. For description of non-structural alternatives see Appendix C.

Discussion of Impacts

Interacting social, economic and environmental factors may bring about both adverse and beneficial impacts to the community. The Water Resource Council's Principles and Standards require that alternative plans continually be evaluated against planning objectives of National Economic Development, Environmental Quality, Regional Development, and Social Well-being. Social, economic and environmental impacts are evaluated to determine which plans best meet these objectives. The following sections discuss the social and economic impacts of the alternative plans.

Impacts of Structural Alternatives

Very few changes will take place with implementation of a structural plan. None of the structural alternatives require land use changes or displacement of residents. The beneficial impact of a structure itself is the protection of oceanfront residences from continuing erosion and inland lots from periodic storm damage. Residents' fears of storm damages and property losses will be reduced with the construction of a protective structure. Two alternatives, placed sandfill and placed sandfill with stone groins, not only will provide protection but also will create additional beach.

At present there are approximately 1,810,000 square feet of dry beach area above the mean highwater line. In terms of capacity, based on a beach use area of 75 square feet per bather and a turnover rate of two, the project area is able to accommodate about 48,266 persons per day. Additional area added by either the placed sandfill or placed sandfill with stone groins would be 990,000 square feet for an increased capacity of 26,400 persons. Adding to the existing capacity, a total of 74,666 persons would be provided beach space with these alternatives. This would satisfy both the week days and peak day demand of today.

The adverse impacts of the project are temporary effects occurring during construction. Materials necessary for each structure include some combination of sand, gravel, and stone.

The transport and placement of these materials will cause local air and noise impacts. The rock, and possibly the sand, required by some alternatives will be trucked to the project site and will create short-run pollution and noise problems and added congestion to local roads. Rather than trucking the sand there is a possibility that it may be pumped from the Merrimack River entrance to the project site. A hydraulic dredge would pump the sand through pipes laid along the beach. Generally, sand is pumped during the spring to limit interference of beach use. Bulldozers are used to place the sand once it has been pumped or trucked onto the beach. The construction of a breakwater would require the use of a barge and tugboats to transport armor stone, and cranes to lift the stone off the barge. Air and noise impacts on a short term basis will again be incurred with the possibility of pollution resulting from fuel spillage.

Significant economic impacts, projected to occur from all but two of the structural plans are (1) reduction in maintenance and repair cost to highways, parking facilities, and private residences required after serious storms, (2) the increased recreational value to the population by protection and improvement of the dry beach area, and (3) increased tax revenues resulting from improvements to the area and an increase in property values.

Public services will be improved with the expanded beach capacity, increased use of leisure time, and minimal increased employment in Newbury and Newburyport.

The two sand placement alternatives will encourage increased recreational usage of the beach by improving the desirability and overall enhancement of the area. These plans will result in increased traffic on U.S. Route 1 and the poor access roads to the beach. This potential liability can be mitigated by local actions and may result in increased business for local establishments such as gas stations, restaurants, and other service facilities.

The rock revetment and nearshore stone mound, which give no protection to the existing beach, may create adverse effects not associated with the other alternatives. Without a beach area, commercial establishments may experience declines in business with the reduction in numbers of day-trippers. Although the island may appear more attractive to buyers and home owners as a result of the improvements, these structures may interfere with the attractiveness of the beach area itself.

Fifty percent of the project costs will be borne by the United States Government and fifty percent by the nonFederal interests. For details of annual cost see Appendix A.

Impact of Non-Structural Alternatives

The nonstructural alternatives identified are evacuation and the relocation. Evacuation would mean the removal of all homes and buildings from the island. Relocation involves moving those homes in critical danger of toppling into the sea to inland lots. The beneficial impact of these alternatives is the reduction of fear of property loss and damages as well as actual losses to those oceanfront residents.

The evacuation alternative will meet great opposition by the Plum Island residents. Permanent removal of inhabitants will destroy existing community ties and affiliations. This alternative does not satisfy planning objectives of protecting land.

The residential section of Plum Island covers approximately the northern one-third of the island. It is estimated that a total of 62 homes in Newbury and Newburyport should be relocated to inland lots over the next 50 years. Since Plum Island covers a relatively small

area, community ties will not be disrupted by the movement of homes from Northern and Southern Boulevards to available town lots. Residents will find their closest neighbors moved to the same area. Other close friends will remain within walking distances.

The relocation alternative will not give the protection brought by a structural alternative. Removing oceanfront property would give no protection to inland and lowland lots from flooding and storm damages.

This alternative would be difficult to implement since there is much opposition. Many of the people who presently own oceanfront property live there only in the summer and do not desire the security of a year-round residence, but want the convenience and enjoyment of the oceanfront. The opposition to relocation not only comes from those wishing to remain on the oceanfront, but also comes from those wanting erosion control for inland protection.

Display of Impacts

Alternatives	Economic Impacts		Social Impacts	
	Beneficial	Adverse	Beneficial	Adverse
Evacuation	Protection of homes	Financial costs of moving homes, obtaining new land	Reduction of fear of losses and damages	disruption of community affiliations
Relocation	Protection of ocean front homes	Financial costs of relocating homes, obtaining new land No protection of inland property from storm damages	Reduction of fear of losses and damages for ocean front property owners	No protection for initial property owners
-- Structural a. Stone breakwater b. Rock revetment c. Nearshore stone mound d. Sandfill e. Groins f. Sandfill & groins g. Dike for Merrimack River	Protection from property losses and damages Reduction of maintenance and repair costs Increased tax revenues Increased property values Increased recreational value (d and f only)	Costs a. $32,323,000 b. 2,541,000 c. 4,131,000 d. 1,677,000 e. 1,750,000 f. 3,408,000 g. 2,694,000	Improvement of public services Aesthetic enhancement with property improvemmts Creation of more spacious beach area (d and f only)	Temporary noise and traffic impacts associated with construction Aesthetically displeasing (a,b,c)

APPENDIX C
MEASURES WHICH CAN BE EMPLOYED BY LOCAL INTERESTS TO REDUCE EROSION AND STORM DAMAGE

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

MEASURES WHICH CAN BE EMPLOYED BY LOCAL INTERESTS TO REDUCE EROSION AND STORM DAMAGE

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MEASURES WHICH CAN BE EMPLOYED BY LOCAL INTERESTS TO REDUCE EROSION AND STORM DAMAGE

As was mentioned earlier in the main report there are a number of non-structural measures which can be employed either in conjunction with structural measures or on their own to help reduce erosion and other related storm damages. These measures can be implemented either by the local governments or private individuals. The following discussion deals with these non-structural measures.

Zoning Regulations

Local governments can institute regulatory controls in the form of zoning regulations pointed toward reducing damage in times of severe storms. This will entail restricting the development to the type of structures which are compatible with a recreational oriented marine environment. Commercial and industrial development which is susceptible to large economic losses during storm conditions should be severely limited or prohibited. Residential lots should be sized to severely limit development in critical damage areas. At the present time Plum Island is zoned for 100 percent residential. In addition, the town of Newbury and the city of Newburyport have increased the requirements for the amount of land which is needed to build on in order to discourage development. Strict adherence and enforcement of these type of zoning regulations is needed in order to derive the maximum amount of benefits from them.

Building Codes

An other form of regulatory control which can be practiced by local governments is to insure that rigid standards are developed for building codes which focus on minimizing the amount of damage sustained by a structure during storm conditions. The structures foundations should be designed to safely withstand minor flooding and that adequate drainage provisions are made to insure elimination of the water after flood conditions. The electrical wiring and fixtures should be properly insulated against the effect of water damage. The sanitary facilities and water supply should be designed and located in areas to guard against being flooded and contaminated during periods of storm conditions which can cause health hazards. Building materials should be such as to be able to withstand high winds and the severe weathering effects of a marine environment.

Sand Dune Use Regulations

Both the local governments and the private property owners on Plum Island can take measures to protect the existing backshore sand dunes against both intentional and accidential destructive practices. These regulations should include items covering the use or restriction of the use of dune buggies or other motorized vehicles on the dunes; protection and preservation of dune grass; prohibition of the removal of material from or other detrimental alterations of the dunes; restriction of foot traffic across the dunes expected in authorized areas and the use of walkways to minimize the effects of foot traffic. All of these measures will help to insure the integrity of the dunes so that they can continue to act as a natural line of defense against the relentless attack of the natural coastal forces.

Storm Warning System

The U.S. National Weather Service provides forecasts of tidal stages and other critical weather parameters during hurricanes and northeasters. It provides continuous storm monitoring and warning service at a number of its main offices including the Boston office. An early warning storm system used in conjunction with an energency preparedness and evacuation program can be very beneficial in minimizing property damage and losses as well as in extreme cases the loss of life. However, in most instances a large amount of time is required to take emergency precautionary measures after the initial storm warnings have been announced. A warning system, no matter how extensive or elaborate, may not allow sufficient time to take adequate precautions due to the erratic behavior of some storms and the velocity with which they move.

Emergency Evacuation Plan

No matter how good a storm warning system is or how many emergency preparedness measures have been taken there are times when an evacuation program will be necessary in order to insure the safety of the people. In anticipation of such an event the local governments in conjunction with the Civil Defense Agency should prepare an emergency evacuation plan of action which can be implemented during times of disaster. This plan should be developed to insure the swift and orderly evacuation of the people on the island, to insure that they are familiar with the procedures and be able to act quickly in times of danger. The U.S. Army Corps of Engineers, New England Division, has already prepared a document entitled "Coastal Storm Preparedness, Plum Island, Massachusetts" which is intended to serve as the genesis for community action. Copies of this document have already been disseminated to local officials and a copy is also included in the end of this appendix.

Dune Grass Planting and Protection

Dune grass is very beneficial in helping to stabilize the sand dunes. It traps the sand material which is being blown off the beach toward the backshore area which helps to nourish the dunes, it helps prevent the sand material from being put back into the air by the wind thus reducing the erosion effects of the wind and it helps to reduce the amount of erosion which occurs due to runoff from storm rains. Measures should be taken by both local governments and private property owners to prevent the existing dune grass from being trampled and destroyed by both foot and vehicle traffic. In addition programs should be initiated to plant additional dune grass especially in critical areas and steps should be taken to periodically maintain and fertilize the grass.

Land Acquisition for open Space Needs and Buffer Zones

There is an ever increasing demand for recreational salt water bathing areas all along the Atlantic coastline. The Plum Island area is no exception. The local governments on Plum Island could help to solve two problems by developing a land acquisition program to help meet the open space recreational needs of the communities as well as providing buffer zones to help protect backshore areas. By buying up land in problem areas and eliminating development in these areas it is possbile to help minimize the effects of erosion and flood damage.

Flood Proofing Structures

The private property owners on Plum Island may take steps on their own to provide floodproofing for their dwellings. Existing structures could be floodproofed by raising some of them where appropriate or by sealing openings to prevent the entry of water. Large electrical equipment and machinery which is located in the basement of structures

such as furnaces, hot water heaters, washing machines and dryers should be elevated on platforms to guard against being damaged during flooding conditions. Temporary measures such as taping windows, sandbagging openings in buildings and moving material which could be damaged may also be employed.

Sand Fences

Both the local governments and the private property owners on Plum Island can utilize sand fences to help minimize the amount of erosion caused by the wind. These sand fences function in a similar manner as does the dune grass by trapping the sand material which is being blown around and preventing it from being lost. The older type wooden sand fences which are made up of wooden slats held together with wire have to be maintained periodically to insure that they are not broken and the shattered wood and broken wire do not pose a problem to the public. New plastic and vinyl fence material is being developed which is lighter in weight and less of a safety hazard than the older type fences.

Public Education and Awareness Program

Probably the most important measure which can be taken by the local governments is that of initiating a public education and awareness program describing the erosion and flood damage which have occurred along the Plum Island shorefront. The potential for additional severe erosion and flood damages during storm conditions should be pointed out to the residences. The various steps that the private property owners can take to help eleviate the situation such as those discussed in this section should be pointed out to them. Technical and other advisory assistance should be made available to them when ever possible and as requested by them.

COASTAL STORM PREPAREDNESS
PLUM ISLAND, MASSACHUSETTS

1. PURPOSE: This document is intended to serve as the genesis for community action.

2. SITUATION: Periodically heavy seas are expected to batter the coastline at high surge levels over successive tidal cycles. Protective beaches and dunes may be severely eroded, thus permitting high water and storm waves to reach backshore development.

3. OBJECTIVES:

a. Establish a warning system which would forecast the effects on the shoreline of approaching storms, thus triggering necessary actions and perhaps evacuation plans.

b. Monitor delineated danger zones wherein endangered persons can be evacuated.

c. Create action plans needed for effecting prompt decisions on the basis of understanding the threats, risks and possible consequences.

4. RESPONSIBILITIES:

a. The U.S. Army Corps of Engineers is not directly involved in natural disaster detection, warning and prediction. The National Oceanic and Atmospheric Administration (NOAA) is responsible for monitoring and issuing forecasts and warnings of meterological and hydrologic phenomena and conditions that affect the Nations safety, welfare and economy.

b. Community preparedness is the ultimate in mitigating the impact of disasters. It consists of vulnerability and risk assessments and planned actions based upon those assessments which are designed to stimulate specific and uniform public response.

The assessment of hurricanes and storm surge risks by timely monitoring of watches and warnings coupled with preparatory actions as announced by a dissemination system is the vital aspect of community preparedness planning.

5. STORM WARNING - DISSEMINATION:

a. Effective dissemination is a vital part of a warning system. For maximum use, warnings must reach all effected members of the community, conveying maximum understanding. (Annex A - Glossary of U.S. Weather Service Terms). This is necessary to allow adequate lead time for making decisions and for taking protective actions to mitigate the effects of the disaster.

b. The news media performs a valuable public service by disseminating forecast and warning information as news.

c. Dissemination directly to the public is accomplished using multiple access recorded telephone announcement (WE 6-1212) systems and VHF-FM Radio (BOSTON KHB 35, 162.40 MHZ) continuous weather transmissions.

d. Police, Fire and Civil Defense circuits are used to assist in the further dissemination of natural disaster warning information. Sirens give communities a rapid and effective means of warning individuals who may not be listening to a radio or TV.

6. PREPARATORY MEASURES (See Annex B)

7. CRITICAL ASSESSMENT AREAS:

a. Location I (North end dunes vicinity of old U.S.C.G. Station) where dunes are breached evacuate surrounding houses and low lying areas to high ground.

b. Location II Turnpike Road (critical evacuation route) once shoreline encroaches and washes over the road there is little if any time left to evacuate using this route.

c. Location III Causeway over tidal flats. Closed at high tides, evacuation plan must be implemented before causeway becoming impassible.

d. Other locations which are roads leading to high ground.

8. ISLAND VULNERABILITY CONDITIONS IV - I

(IV) a. Minor flooding (little structural damage)
Good beach depth (150 + feet)
Dunes repaired in good condition

(IV) b. Flooding near beach (minor structural damage to shorefront structures)

Moderate beach depth (100+ ft.)
Minor dune damage exists

(III) Some inland flooding (severe damage to shore front structures)
Less than 100 (-) foot of beach exposed major dune damage prevailing.

(II) Severe flooding well inland (structural damage first block) 50 foot of beach, exposed dunes near non-existent or rapidly deteriorating.

(I) Major disaster conditions - (Dangerous flooding and severe structural damage well inland from beach)

Less than 50 foot of beach exposed dunes and dikes absent

9. EVACUATION CRITERIA:

a. General: Breaching of dunes and dikes, which constitute the first line of defense, is a primary assessment factor. Rapid destruction of the beach and subsequent erosion is generally a function of easterly winds, tide heights, duration of storm and intensity. The worst time for a storm to strike, from an evacuation planning standpoint, would be when citizens are asleep at night. Seasonal variations in beach vulnerability conditions will effect available reation time depending on whether the beach was accreting or erroding.

b. In a minor storm with beach assessed to be in excellent condition and tide at low ebb there should be little cause for concern. Condition (IV)a and (IV)b.

c. In a minor storm with beach assessed to be in fair condition and high tide prevailing evacuation of endangered persons to high ground must serviously be considered. Condition III.

d. In a major storm with beach assessed to be in fair condition and any tide level, evacuate with haste to the south or off island. Condition II.

e. In a major storm with beach assessed to be in poor condition, expeditiously evacuate south or off island. Condition I

10. ACTIONS DURING STORM (See Annex C)

11. Post Storm (Disaster) Recovery (See Annex D)

ANNEX "A"

GLOSSARY OF U.S. WEATHER SERVICE TERMS

ADVISORY: Normally issued three times daily and give specific information on the storm's position, intensity, direction and speed of movement, and designate areas of the coast that are under watch or warning.

WATCH indictive of hydro-meterological conditions which are conducive to the development of flooding.

WARNINGS are issued for specific locations where flooding is imminent or in progress.

BULLETIN: The fastest means of issuing priority weather data to the public. It is a statement which consolidates broad storm situtation data, issued whenever there is a reasonable expectation of severe weather conditions developing.

STATEMENT: Is a local supplement, normally issued following a bulletin.

ANNEX "B"

PREPARATORY MEASURES

a. Designate person (and alternate) to be in charge as well as staff

b. Establish Emergency Operations Center (Command Post)

c. Determine communication needs and preposition

d. Identify Locations for road blocks and/or traffic control

e. Stockpile filled sandbags (obtain bags from Mass. C.D.)

f. Floodproof buildings, tie down loose items outdoors

g. Identify flood fighting crews

h. Establish danger zone reconnaisance patrols

i. Designate local high ground, southern, or off island evacuation centers

j. Stock first aid supplies. Conduct first aid training

k. Practice, test, alert system

l. Preposition emergency and/or evacuation equipment. Prior to high tide isolating island

m. Designate and mark evacuation route(s)

n. Assess degree of protection afforded (vulnerability) by existing beach profile in conjunction with the magnitude potential storm threat

o. Stress need for family evacuation/storm kits (Annex E)

p. Identify rescue crews

q. Write and publish detailed plan

r. Educate public as to planned actions

ANNEX "C"

ACTIONS DURING STORM

a. Activate Emergency Command Center

b. Conduct communications checks

c. Monitor weather reports

d. Post watches/patrols

e. Alert flood fight rescue crews

f. Activate road blocks and traffic control points

g. Continuously monitor critical areas (danger zone) and announce re-evaluated beach assessment condition.

h. Liaison w/U.S. Coast Guard, Red Cross

i. Evacuate as situation would dictate

j. Provide for security of island when in evacuated posture

k. Secure utilities when buildings are vacated

ANNEX "D"

POST STORM ACTIONS

a. Assess disaster situation and decide as to which and when inhabitants may safely return to island

b. Restore utilities

c. Clean up debris

d. Assess public damages

e. If warranted establish relief centers for meals, shelter, clothing, lodging, medical care

f. Request County of Commonwealth supplemental assistance as needed

ANNEX "E"

INDIVIDUAL STORM KITS

To be stocked by homeowners should storm interrupt utilities or accompany family in the event of evacuation.

Candles

Flashlight w/extra - batteries

Portable radio

Canned food

5-gallon water can

Canned heat (sterno) to cook with

Blankets

First aid kit

Rope

Road map marked w/evacuation route(s)

Extra-clothing deemed necessary for season

Masking tape

APPENDIX D
GEOLOGY

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

GEOLOGY

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PLATE

Regional Geology

Plum Island is located in the northeast corner of the state of Massachusetts and lies within the seaboard lowland section of the New England physiographic province. The seaboard lowland section in this area has an irregular topographic surface with a maximum elevation of approximately 350 feet gently sloping toward the coast. The topography is characterized by many low hills of unconsolidated glacial material with rock exposures providing local relief particularly in the Cape Ann area.

Stream valleys and drainage areas are poorly defined resulting in extensive interior swamps and coastal marshes. Tidal marshes are extensive in the immediate vicinity of Plum Island and extend inland a distance of 3-6 miles along the major tributaries. This generally sluggish drainage system coupled with a rising sea level has caused the development of saltwater peat deposits in the coastal marshes.

Inland from the coast, the unconsolidated glacial deposits overlying the bedrock form gently sloping low relief features of highly variable composition. Complex glacial outwash and former shore deposits lie 10 to 15 miles inland from the present shore line and are represented in many areas by extensive sand plains. (See Figure 1)

The bedrock of the area has influenced the drainage pattern of the region. The course of the Merrimack River as far east as Amesbury, Massachusetts is largely confined to a bedrock belt of relatively soft lower palezoic phyllite and shaly quartzite. At Amesbury the softer rocks turn north to parallel the coast while the Merrimack River continues eastward to the sea, transversing harder rocks but of decreasing relief owing to the seaward sloping of an old peneplaned surface.

The topography of the area has had an extensive influence on the history and development process of the area. Areas of similar geomorphology have developed around similar geologic restraints except where influenced by the more urban climate of major cities.

(1) Ref. USGS Bulletin No. 7 "The Geology of the Court of Northeastern Massachusetts" by Newton E. Chute and R. L. Nicols dated 1941.

Site Geology

Plum Island is a typical barrier beach between seven and eight miles long varying from one half to one mile in width terminating in Kames and ground moraine features at its southern tip (see Fig. 1). These figues are formed as the result of a rising land surface or a falling sea level attempting to restablish the offshore profile essential to a beach equilibrium. These long narrow islands or spits lying parallel to the shoreline are characteristic to the entire east coast of the United States particularly from Long Island to Mexico. The normal growth sequence of the barrier beach is that during storms sands is shifted outward to form a submerged offshore bar, and that during the ensuing quieter conditions this sand is wholly or in a large part moved back to the beach. This sequence of events which would normally receive additional beach building materials from long-shore drift plus the in-and-out movements of sands associated with the creation and destructions of storm bars is interfered with at the northern end of Plum Island by the Merrimack River estuary. The building sequency of the island is shown on plate D-1 "Shoreline-Change Map" where prior to 1880 and construction of the jetties, the dynamics of Plum Island is shown to respond to the available material from Salisbury Beach to the north and the influence of the discharge water from the Merrimack River. The patterns of deposition and scour indicates the balance of material and the effect of the constantly discharging river. The prominent curving of the earlier spit (prior to jetty construction) upstream is to be anticipated under the above conditions. At the end of the spit some material is swept landward by the flood-tide and other material is swept seaward by the ebb-tide and river currents. The material that is swept seaward, however, is continually removed by the waves and long shore currents, whereas a large amount of the material swept landward remains there and the spit therefore tends to curve inland.

This dynamic action of material balance was modified in the early 1880's by the establishment of the north and south jetty which fixed the inland land mass at the outer end. With these points fixed any material being discharged from the Merrimack could only reach the eastern shore of the island by being deposited beyond the south breakwater and drifting southerly with the normal long shore drift. Storms may destroy this pattern temporarily and depending on their severity larger portions of the shore may be eroded. However, the trend of building an offshore bar as a result of material loss from the northern part of the island is shown on Figure 2. This offshore bar is generally extending to the south and increasing in width thus closing the channel between the bar and the island.

A review of the surveys and aerial photographs showing the erosion pattern from 1966 to 1976 of the northern section of the eastern shore of Plum Island versus the volume and location of material in the offshore bar indicates a constant southerly movement of the most critical areas of erosion consistant with bar building. This pattern of a prograding shoreline as the bar is moved shoreward is consistent with the building of a typical barrier beach feature. The present surveys indicate a geologic feature which is becoming stabilized against the rigid structures. South of the development area to the Rowley town line Plum Island appears to be unaffected by the Merrimack River and is operating as a typical barrier beach with a relatively uniform offshore profile.

Ground Water

No detailed records of the ground water resources of Plum Island are available. Discussion with local officials indicate that the island homes are completely dependent on individual wells as there is no central water system and no water is pumped to the island. The water balance of the island discharge vs recharge is completely dependent upon rainfall for recharging the acquifer. There is practically no surface runoff as indicated by the low density of surface channels. Of the total precipitation some is evaporated directly from the land surface while some is evaporated or transported from the soil, and the remainder seeps through the soil to the water table and recharges the groundwater reservoir. Water in the reservoir moves from points of high head (high altitudes of the water table) toward points of lower head and ultimately is discharged to the ocean as ground-water outflow. Enroute to the ocean some ground water is discharged naturally to the atmosphere by evapotranspiration and some is discharged artificially by pumping wells a portion of which returns to the ground water reservoir through septic systems.

Fresh ground water is slightly less dense than salt water and therefore "floats" as a lens-shaped body upon underlying saltwater in the ground-water reservoir. The lower boundary of the fresh water lens is called the fresh water/saltwater interface. This interface is not a sharp boundary but is a zone of mixing or diffusion of fresh and saltwater.

No specific information is available from wells to define the ground water level, however, visual observations of the edges of the island did not show evidence of erosion channels on the beach caused by a surplus of fresh water discharge. These observations and the lack of drainage channels would indicate that there is minimal of ground-water overflow from the island.

Construction Materials

Materials are available from several sources for construction projects on the island. Depending on the quantity and physical properties required the distance of the source from Plum Island will vary,

a. STONE.

Sources of stone for use as riprap dimension stone are available within a 30 mile haul distance of the site. Depending on the size of the stone required larger dimension stone may necessitate greater haul distances.

Previous work at the stie in 1970 obtained the smaller sizes 0-3 ton range from the J. Iafolla Quarry in Portsmouth, N.H. and the 3-8 tone size by barge haul from the Deer Isle Quarry in Dear Isle, Maine.

Suitable sources of stone have also been available from intermittently operated quarries in the town of Rockport, Massachusetts. These sources have previously provided quarry stones in the 6-8 ton range.

b. SAND FOR BEACH PLACEMENT.

Four areas are considered as possible sources of sand for use as beach replacement (1) offshore at the mouth of the Merrimack River (2) offshore from the beach north of Turnpike Road (3) truck haul from land sources approximately 15 miles to the west and northwest of the project site (4) rail haul from operating pits presently supplying the Boston Area from New Hampshire.

1. Sand material from this area could be supplied from required dredging of the navigation channel. Samples were not obtained of this area during this study, however, previous experiences indicate that it would provide a satisfactory source of beach fill.

2. Use of the offshore bar as a source of sand is desirable from a location standpoint since it is immediate to the area of required work. Excavation of this area should be done only with caution as creation of an opening in the bar could lead to a change in the erosion pattern of the shoreline.

3. As part of this investigation an existing pit was sampled in the town of Kingston, New Hampshire approximately 15 road miles from the site. The pit presently used by the New Hampshire Department of Public Works is located on Route 107, one mile west of its junction with Route 125. A typical gradation curve of a pit run sample is shown on Figure 2. A more detailed investigation could possibly discover sources 1 to 5 miles closer to the project site.

4. The use of sand from a source with rail facilities was investigated with the possiblity of hauling to a siding in Newburyport. A grain size curve is included (Figure 3) for material located in Ossipee, New Hampshire. This pit is presently owned by the Boston Sand and Gravel Company.

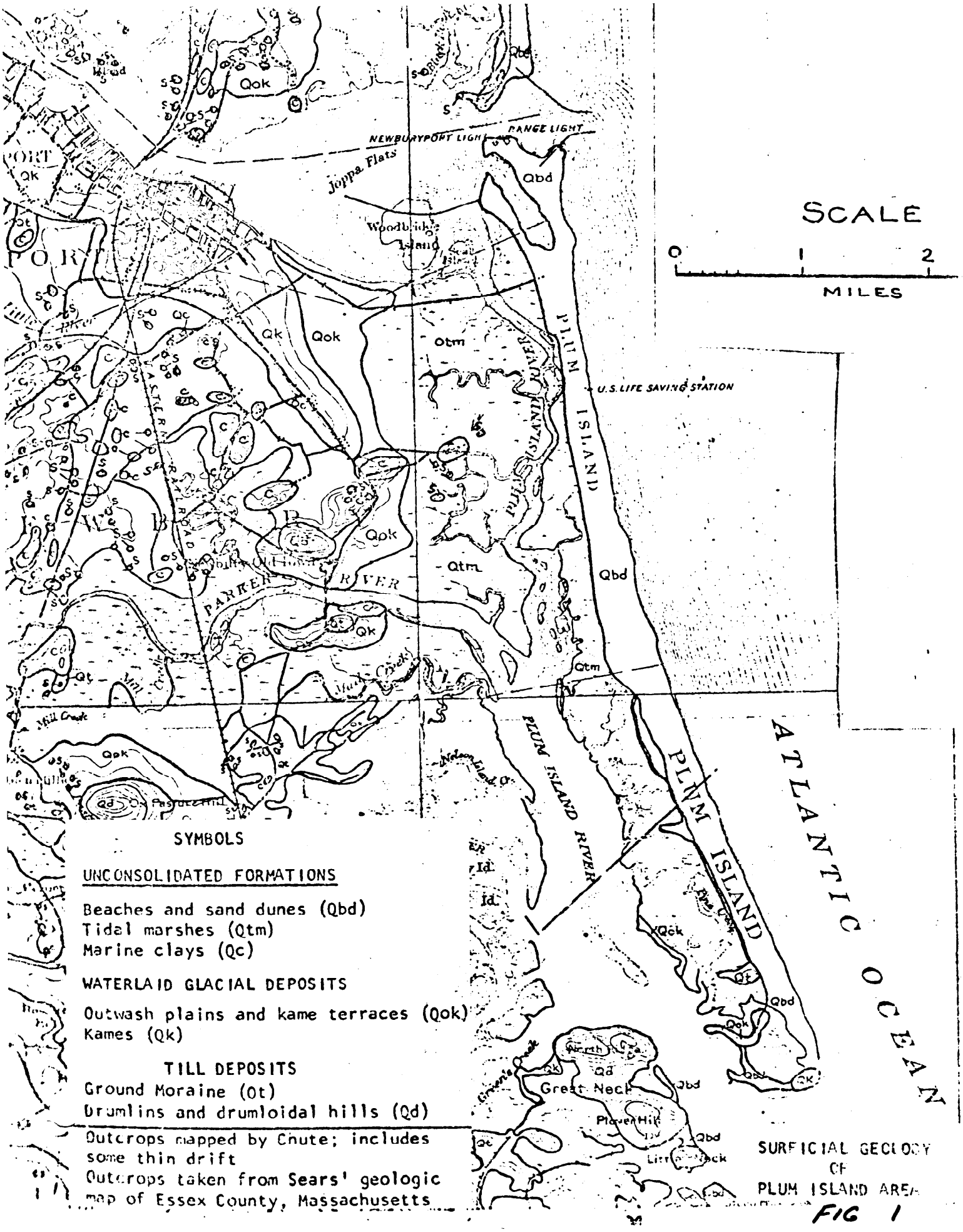
Conditions of Special Engineering Significance

1. Any structural solution should give consideration to the long term effect on possible shoreline modifications.

2. Material excavation from water sources in the vicinity of the island should give consideration to its effect upon the present shoreline development.

3. Additional studies should consider bottom profiles south of the Turnpike Road to substantiate the assumed offshore profile.

4. Any Merrimack River channel modification should give consideration to the long term effect upon the Plum Island Shoreline.



SURFICIAL GEOLOGY OF PLUM ISLAND AREA

FIG 1

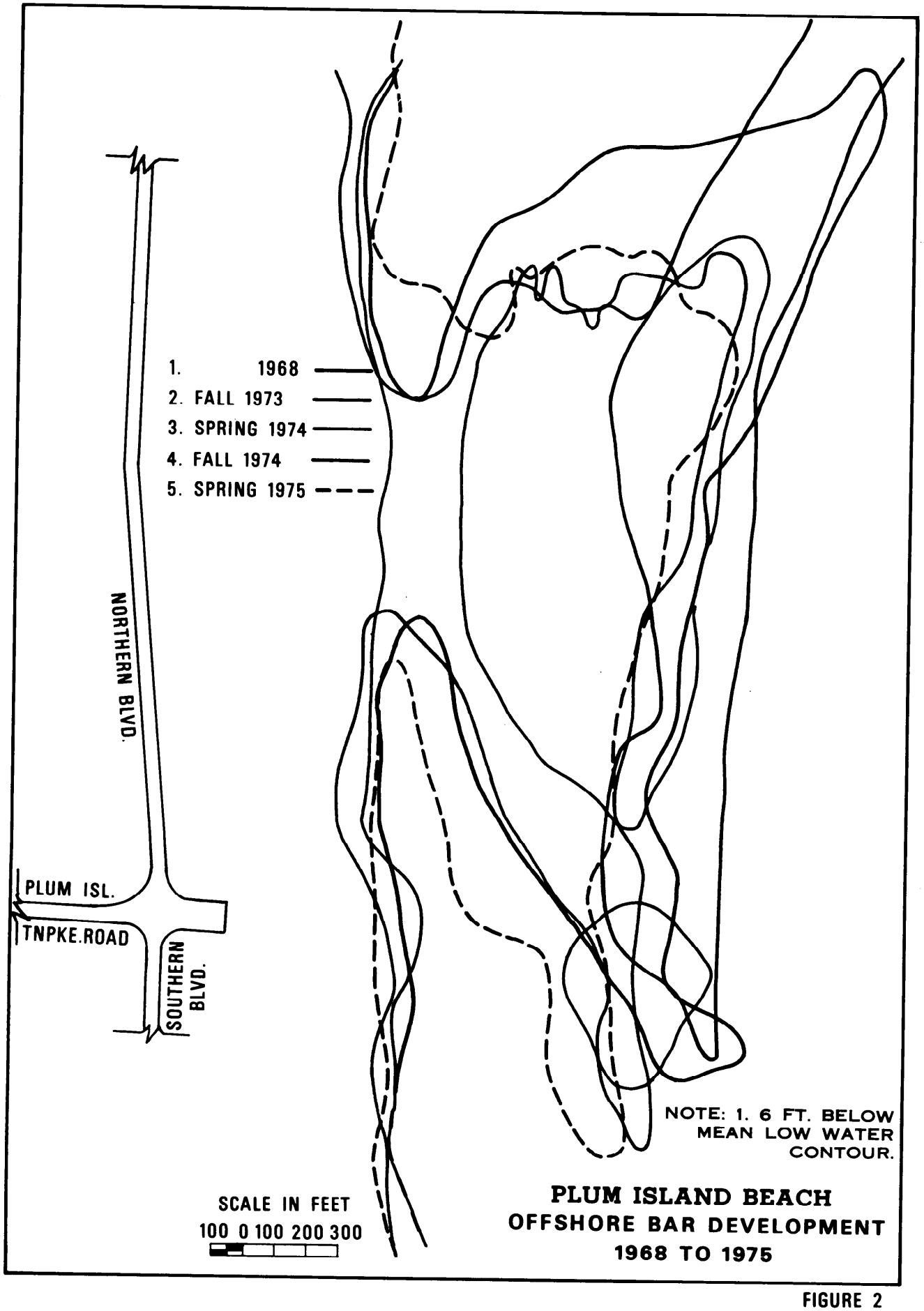
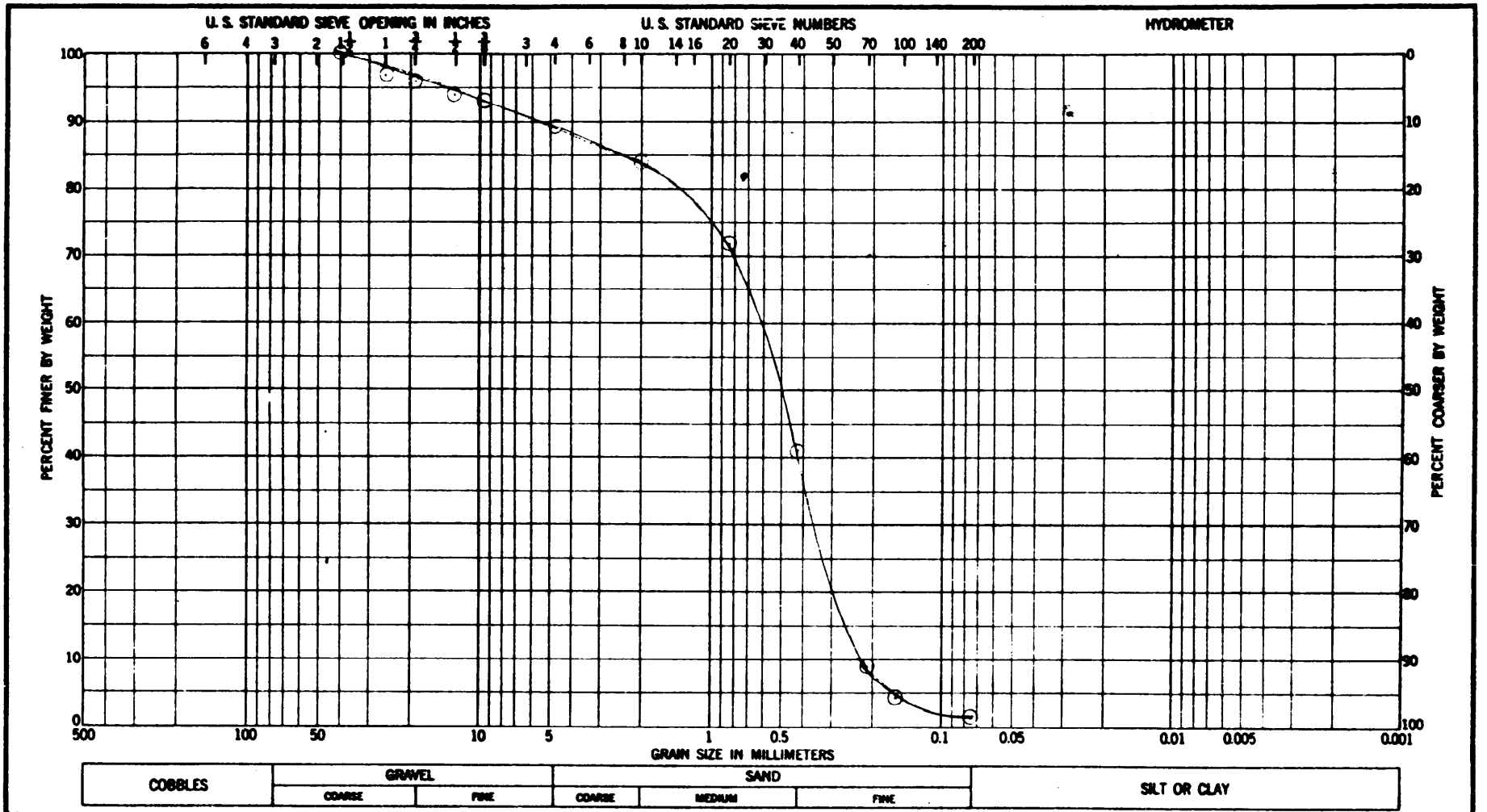

1. 1968
2. FALL 1973
3. SPRING 1974
4. FALL 1974
5. SPRING 1975
NORTHERN BLVD.
PLUM ISL.
TNPKE.ROAD
SOUTHERN BLVD.
NOTE: 1. 6 FT. BELOW MEAN LOW WATER CONTOUR.
SCALE IN FEET
100 0 100 200 300
PLUM ISLAND BEACH
OFFSHORE BAR DEVELOPMENT
1968 TO 1975

FIGURE 2



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1		Gravelly SAND (SP)				

GRADATION CURVES

Project PLUM ISLAND

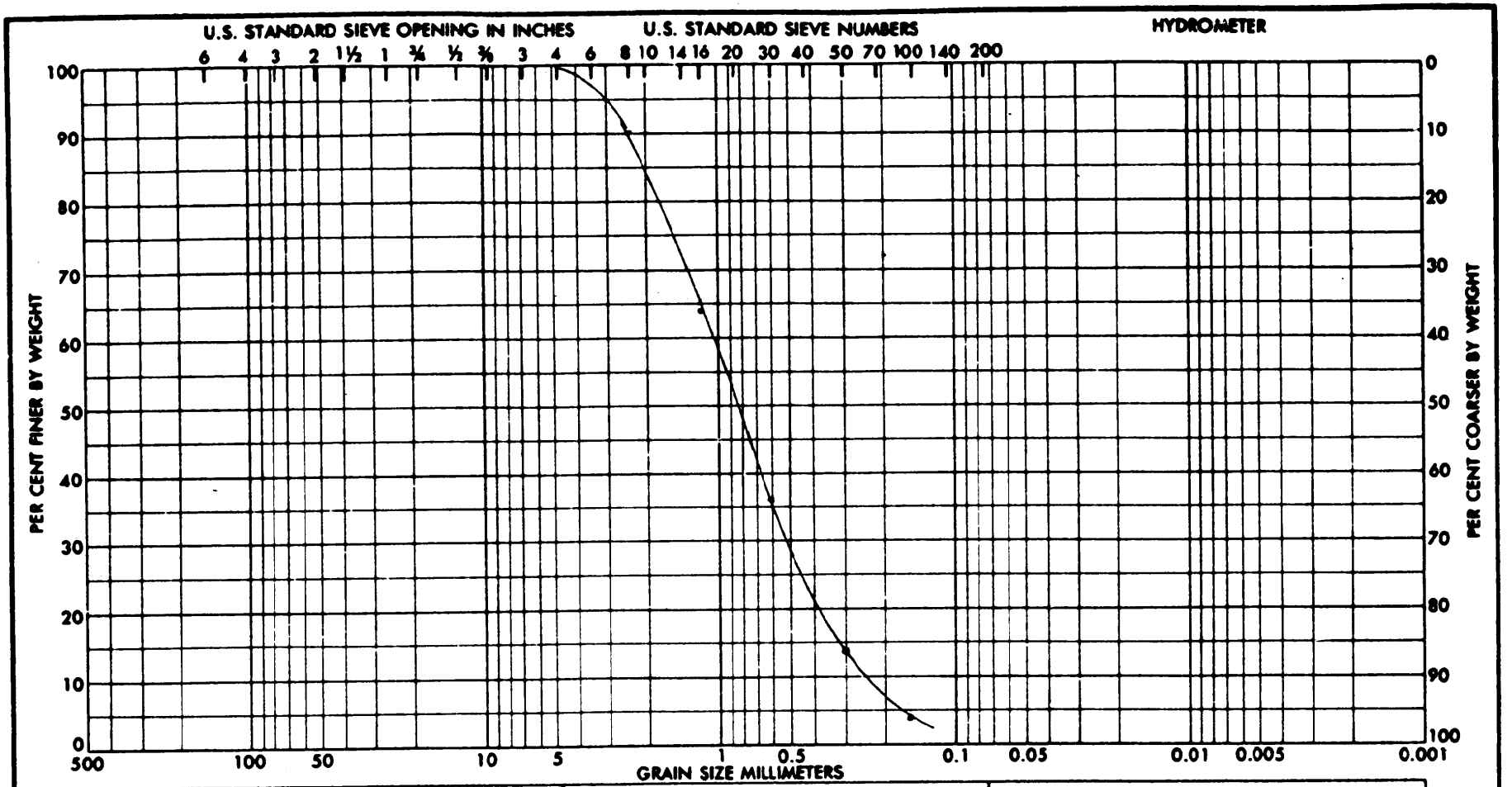
Area KINGSTON N.H

Boring No. PT- 1

Date Sept. 22, 1976

FIG. 3.

ENG FORM 1 MAY 63 2087



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI

GRADATION CURVES

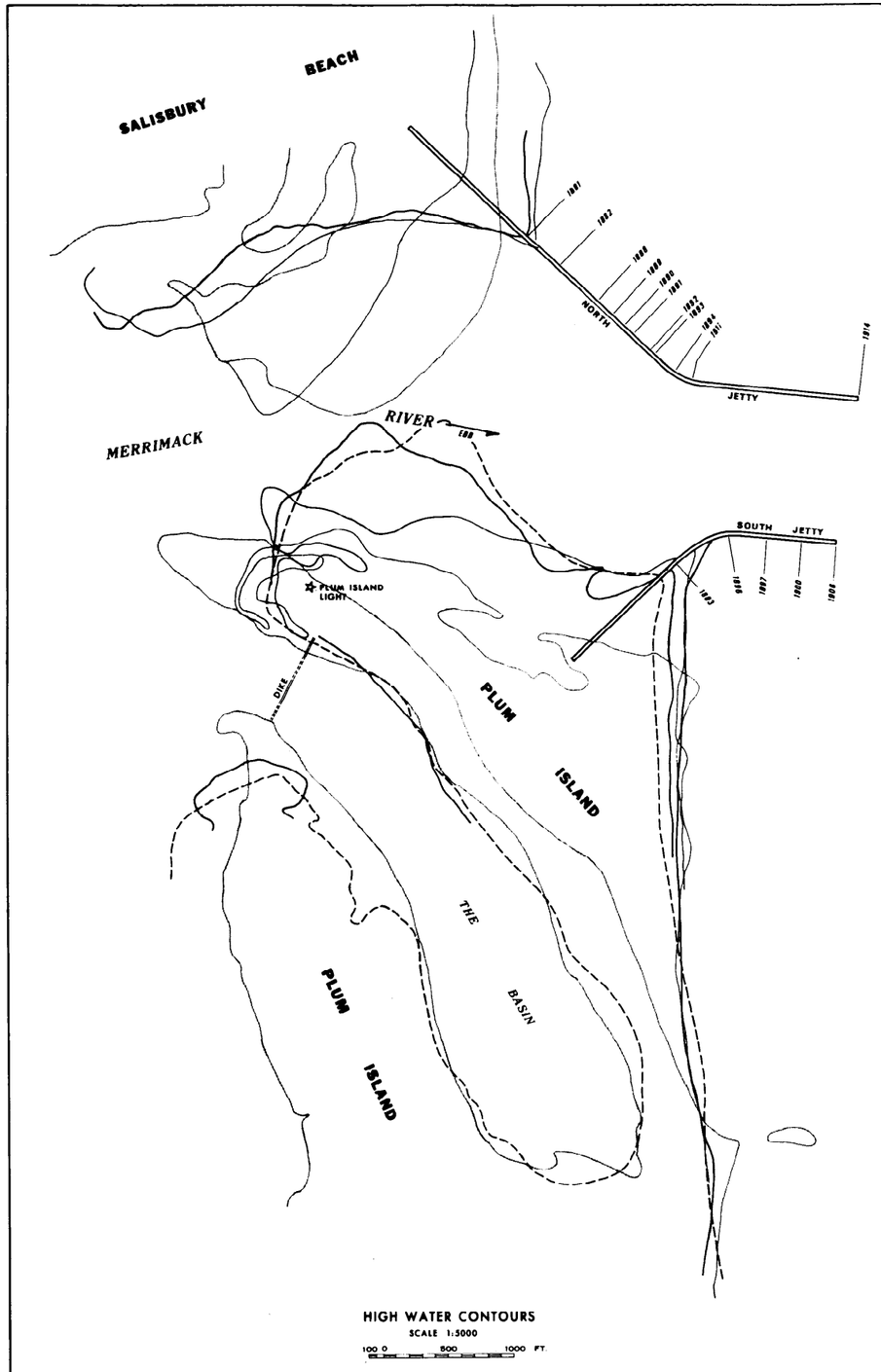
PROJECT PIUM ISLAND
SAND SAMPLE
AREA OSSIPEE NH
BORING NO. - Concrete Sand
DATE 9/22/76

Fig. 4.

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

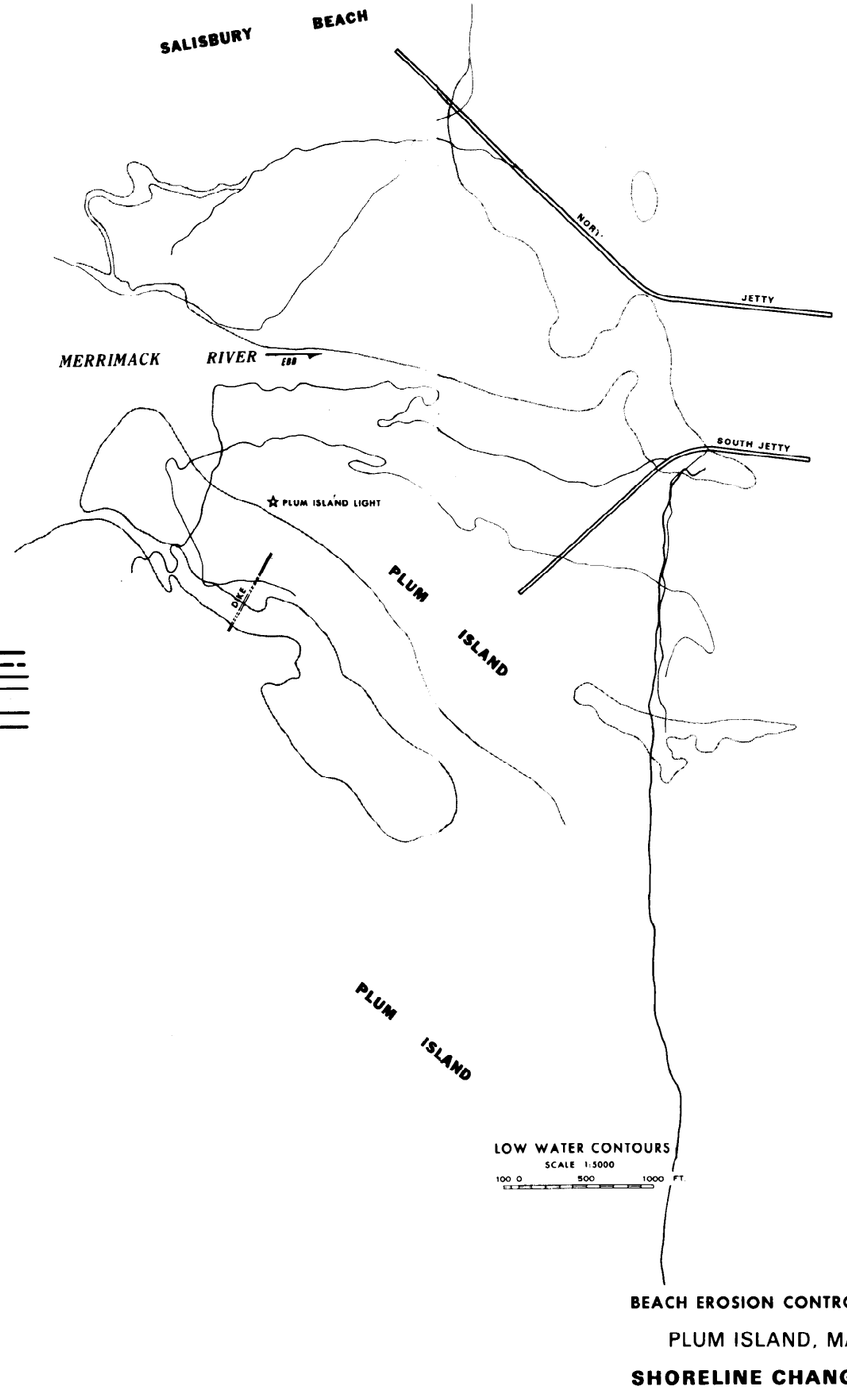
U.S. GOVERNMENT PRINTING OFFICE : 1963 OF—700-126



HIGH WATER CONTOURS
SCALE 1:5000
100 0 500 1000 FT.

N

LEGEND
1974
1940
1931
1912
1890
1880
1851
1827



LOW WATER CONTOURS
SCALE 1:5000
100 0 500 1000 FT.

BEACH EROSION CONTROL STUDY

PLUM ISLAND, MASS.

SHORELINE CHANGE MAP

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE D-1

APPENDIX E
DESCRIPTION,COMPOSTION OF SHORE AND PROTECTIVE STRUCTURES

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

DESCRIPTION COMPOSITION OF SHORE AND PROTECTIVE STRUCTURES

TABLE OF CONTENTS

PLATES

DESCRIPTION COMPOSITION OF SHORE AND PROTECTIVE STRUCTURES

General

The data concerning the shoreline and the protective structures along Plum Island has been obtained from field investigation and historical data available from the city of Newburyport, the town of Newbury and the Commonwealth of Massachusetts. The study area is about 4.5 miles long and includes 2,000 feet of shoreline along the south shore of the Merrimack River and then south to the Newbury-Rowley town line. (See Plate A-1) The following is a detailed description of the area.

1. Merrimack River Section, Profile 1 thru Profile 4

a. Location. - Between profile number one and the south jetty.

b. Shore Length. - 2,000 feet.

c. Ownership. - United States Coast Guard.

d. Public Facilities. - None

e. Composition of Shore. - The shore is exclusively composed of well graded sand.

f. Protective Structures. - Rock revetment built by the Corps in 1970 along the inner end of the south jetty. Also, the south jetty constructed by the Corps, beginning in 1880 and extended four times, completed to its present length in 1906.

g. Beach Width Above M.H.W. - On this section of the shore there is about 150 feet of beach fronting the first row of houses at the narrowest section and about twenty five feet of dry beach fronting the buildings that were the temporary quarters of the Coast Guard.

h. Character of Development. - Government property, used by the public for fishing.

i. History of the Shore. - As a result of two northeast storms occurring between 9 and 27 February 1969 this section of shore was seriously eroded, endangering the Coast Guard station located at the entrance to the river. The Corps completed a rubble mound erosion protection fronting the Coast Guard station to protect the south jetty structure from being flanked. Also a sand dike was pumped along the south shore of the Merrimack River. The rubble mound structure and the sand dike were completed in September 1970. The rubble mound structure is in good condition but the sand dike is completely eroded away.

2. Profile 4 thru Profile 9

a. Location. - Between the south jetty and the turnpike groin.

b. Shore Length. - 6,000 feet.

c. Ownership. - The northern 1,200 feet is owned by the Coast Guard, the remaining 4,800 feet is private shore.

d. Public Facilities. - None.

e. Composition of Shore. - Well graded sand beach.

f. Protective Structures. - The Commonwealth of Massachusetts constructed five groin structures between the years 1954-1957 to retard excessively high sand losses along the beach. Also, the Commonwealth in the mid-sixties, rehabilitated several of the groins and added a limited amount of revetment along the backshore in the vicinity of profile 8.

g. Beach Width Above M.H.W. - The beach width varies, the beach is wider at the south jetty and somewhat narrower as you proceed south, with irregular widths in between. The average width is about 250 feet.

h. Character of Development. - The northern 1,200 feet is Government property. The remainder is privately owned except for an 800 foot section of beach north of profile No. 9, which is public beach. The backshore along this 4,800 foot section of the island is all private cottages and homes. The beach is used by the public for swimming and fishing on a limited basis.

i. History of the Shore. - The shorefront along this section of the island has over the past decade undergone drastic changes. In the early 60's several property owners had gone to the expense of constructing rock revetment along their property because of the threat of erosion. Then, there was little or no beach fronting their homes, today, these homes enjoy about 250 feet of dry beach fronting their homes. The Commonwealth in 1953 placed about 560,000 cubic yards of sandfill along the beach beginning at about the Plum Island Turnpike and extending in a northerly direction for about 3,000 feet. The Corps in April 1973 placed sandfill along about 800 feet of seriously eroding shore north of the turnpike groin. This work was done under section 103, small beach erosion control authority.

3. Profile 9 to the Parker River Wildlife Refuge

a. Location. - Between the turnpike road and the boundary of the Parker River Wildlife Refuge.

b. Shore Length. - 3,800 feet.

c. Ownership. - Private.

e. Composition of Shore. - Mixture of coarse and medium size sand

f. Protective Structures. - This section of shorefront has two groin structures, both constructed by the Commonwealth between 1954-1957. Several property owners have dumped at random loose rock and gravel and placed several rows of precast concrete blocks along the base of the dunes to help retard the erosion.

g. Beach Width Above M.H.W. - The dry beach width in this section varies drastically, the section between profile 9 and 10 is badly eroded. One house has fallen over the bank and several others were moved back. The beach width between profile 9 and 10 averages about 30 feet. South of profile 10 to the Wildlife Refuge the average width is about 175 feet.

h. Character of Development. - The area is primarily private homes and summer cottages except for the southern 500 feet of this section, which is private and undeveloped.

i. History of the Shore. - The section of shore between profile 9 and 10 was seriously damaged this fall, during a series of storms accompanied by high spring tides. The shorefront was badly eroded, valuable dunes and blufffs were destroyed or damaged. One cottage slid down a twenty foot embankment and two other cottages were moved landward. The remainder of the shorefront south of profile 10 has periodically been cut back but at the present time enjoys about 150 to 200 feet of dry beach area above the mean high waterline.

4. Parker River Wildlife Refuge to the Newbury-Rowley Town Line

a. Location. - Southern limit of the study.

b. Shore Length. - About 14,000 feet.

c. Ownership. - United States Government.

d. Public Facilities. - Small beach, about 100 feet long with portable bathhouse and parking area, also the wildlife refuge accomodates people for bird watching, fishing and sun bathing.

e. Composition of Shore. - Sandy beach fronting low-lying dunes.

f. Protective Structures. - None.

g. Beach Width Above M.H.W. - About 175 at the north limit of the refuge and about 250 feet at the Newbury-Rowley town line.

h. Character of Development. - The area is a Wildlife Refuge operated by the U.S. Fish and Wildlife Service. The area provides bird watching, fishing and beachcombing. This also includes fostering the wisest use of land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation.

j. History of Shore. - The park service reports that the shoreline changes from season to season. Occasionally, during northeast storms sections of the beach will erode and the base of the dunes will be exposed to erosion or a breakthrough will occur. In general the area is stable, with no major erosion problems.

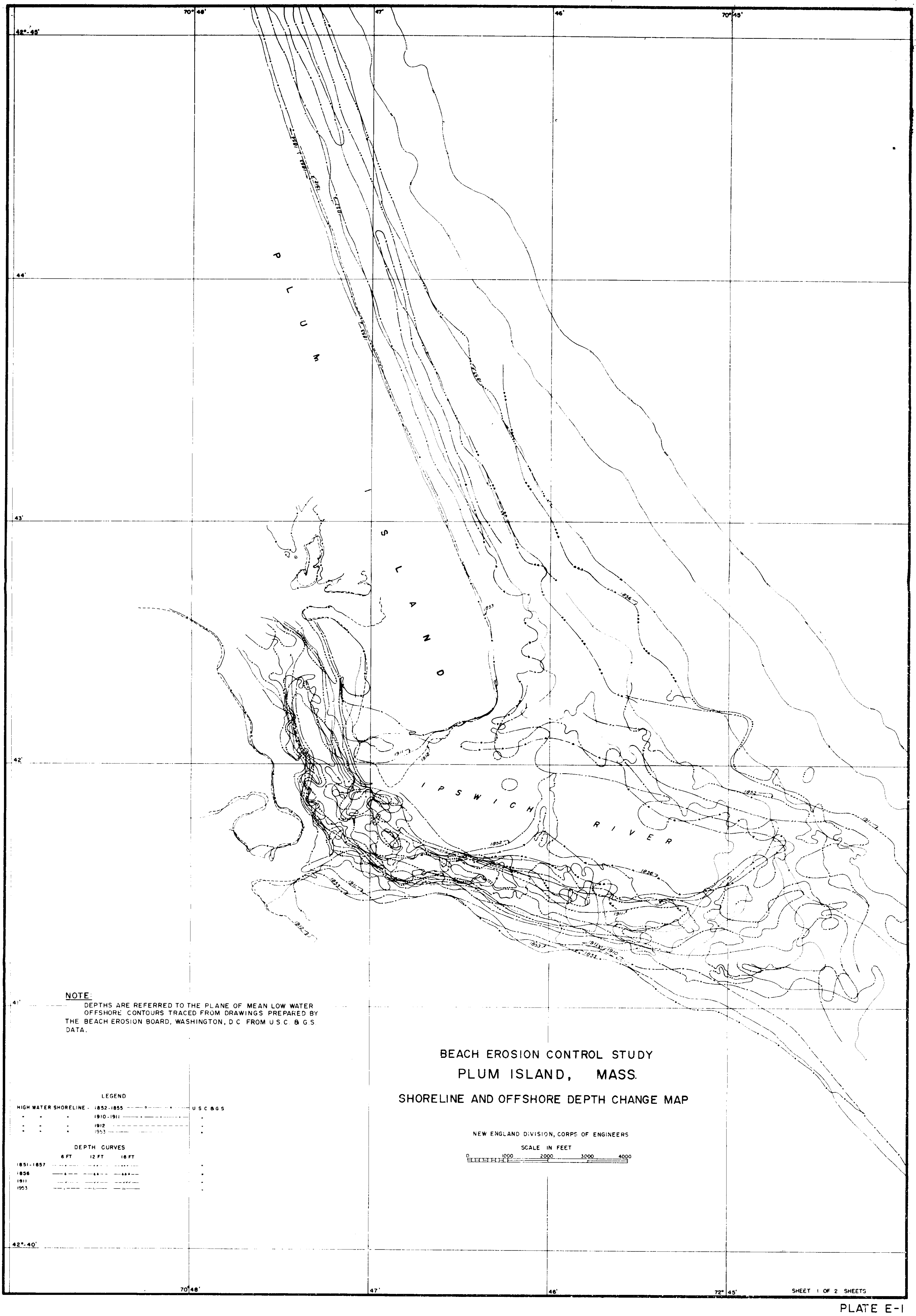
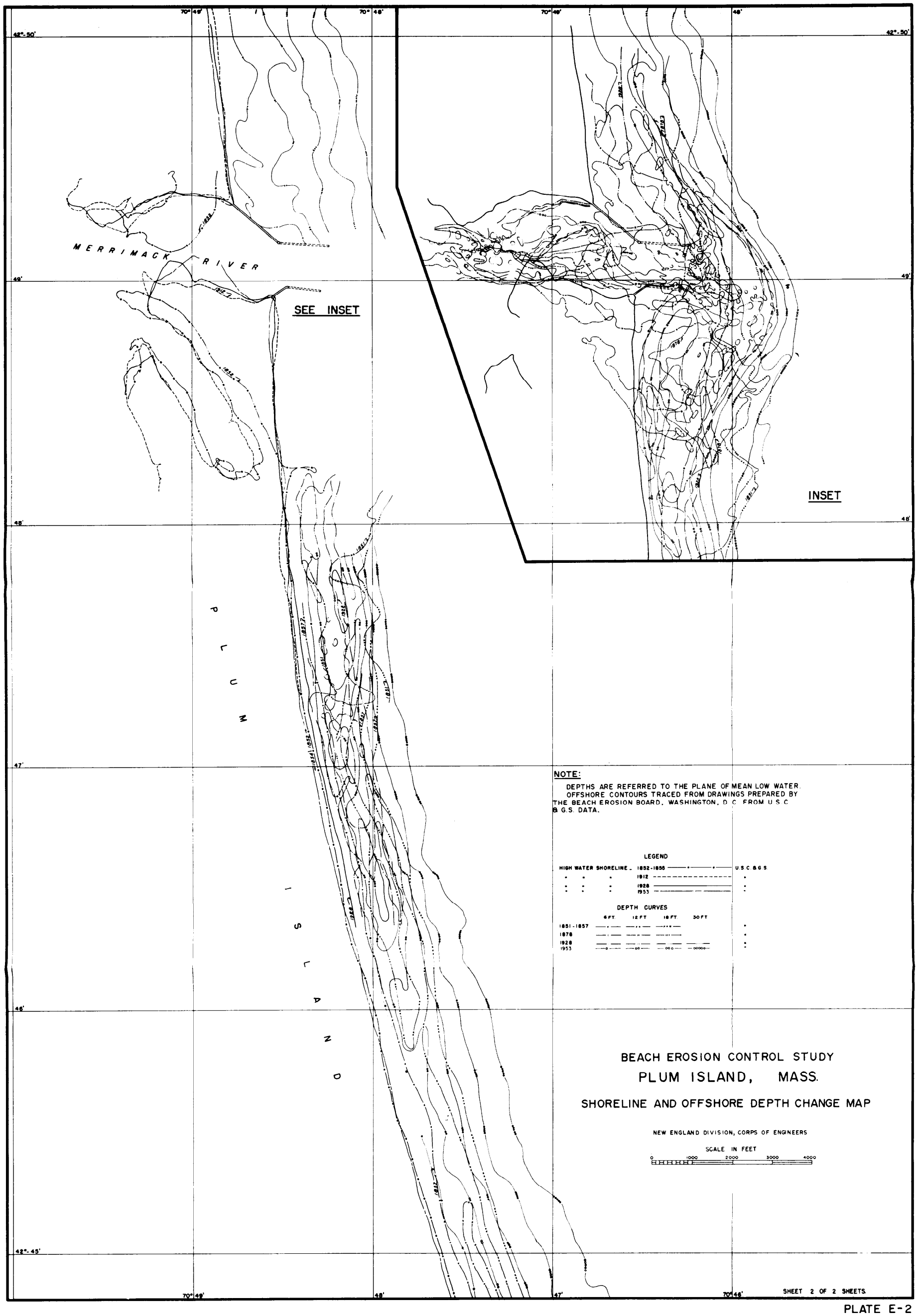

70° 48'
47'
46'
70° 45'
42°-45'
44'
43'
42'
41'
42°-40'
PLUM ISLAND
IPSWICH RIVER
1853
1912
1857
1856
1852
1911
1910
NOTE:
DEPTHS ARE REFERRED TO THE PLANE OF MEAN LOW WATER
OFFSHORE CONTOURS TRACED FROM DRAWINGS PREPARED BY THE BEACH EROSION BOARD, WASHINGTON, D.C. FROM U.S.C. & G.S. DATA.
LEGEND
HIGH WATER SHORELINE - 1852-1855 U.S.C.&G.S.
1910-1911
1912
1953
DEPTH CURVES
6 FT
12 FT
18 FT
1851-1857
1856
1911
1953
BEACH EROSION CONTROL STUDY
PLUM ISLAND, MASS.
SHORELINE AND OFFSHORE DEPTH CHANGE MAP
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
SCALE IN FEET
0
1000
2000
3000
4000
72° 45'
SHEET 1 OF 2 SHEETS

PLATE E-1



NOTE:

DEPTHS ARE REFERRED TO THE PLANE OF MEAN LOW WATER.
OFFSHORE CONTOURS TRACED FROM DRAWINGS PREPARED BY THE BEACH EROSION BOARD, WASHINGTON, D.C. FROM U.S.C. & G.S. DATA.

LEGEND

HIGH WATER SHORELINE — 1852-1856 — U.S.C. & G.S.
1912
1928
1953

DEPTH CURVES

	6 FT.	12 FT.	18 FT.	30 FT.	
1851-1857					*
1878					*
1928					*
1953					*

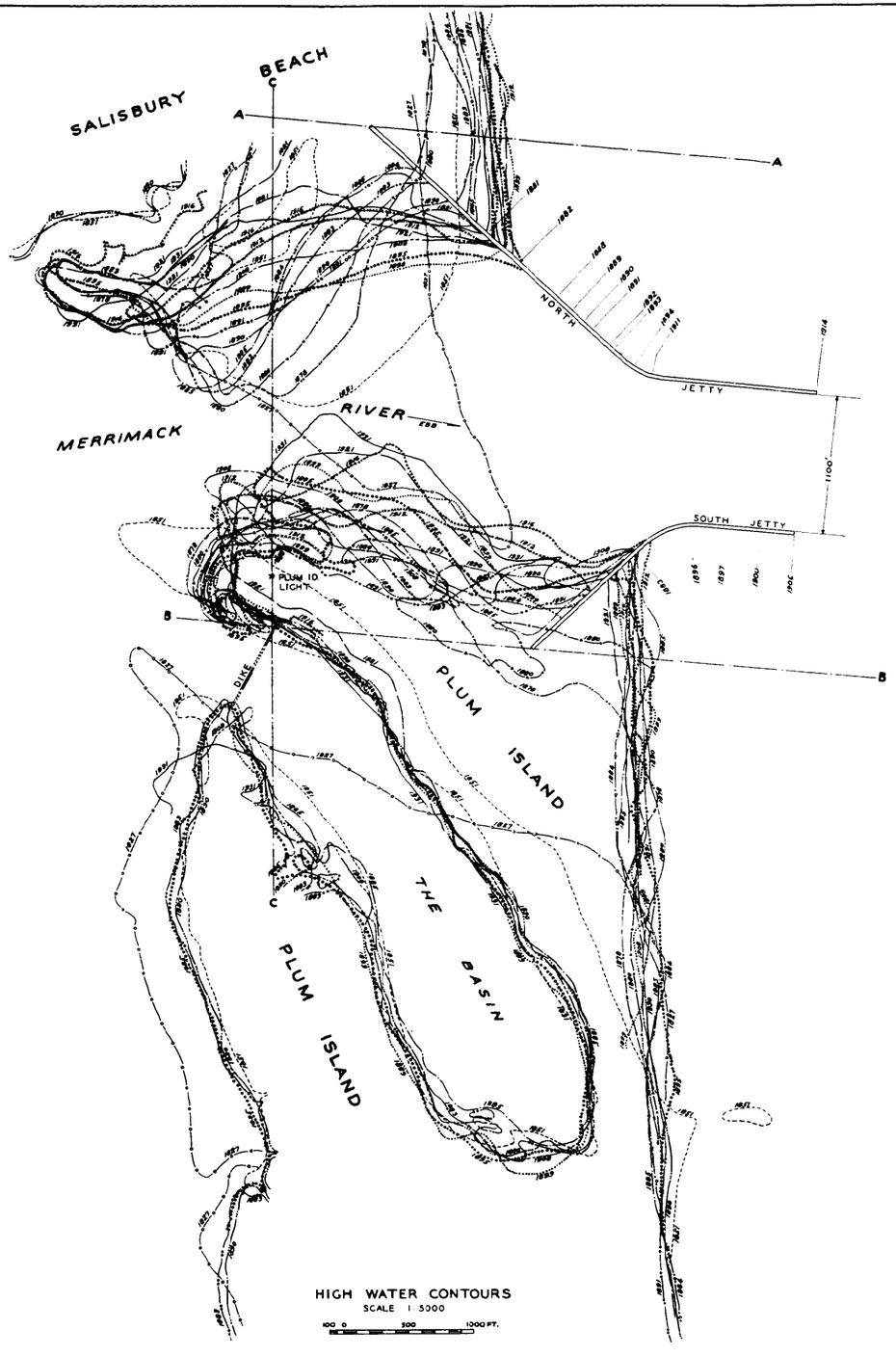
BEACH EROSION CONTROL STUDY
PLUM ISLAND, MASS.
SHORELINE AND OFFSHORE DEPTH CHANGE MAP

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

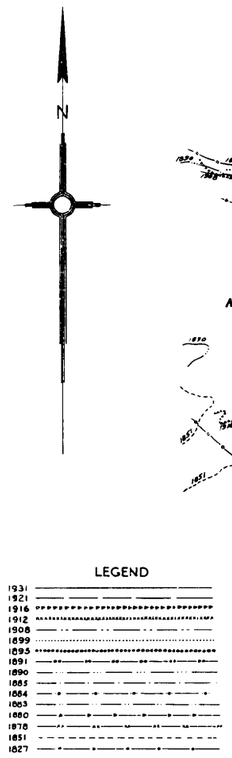
SCALE IN FEET
0 1000 2000 3000 4000

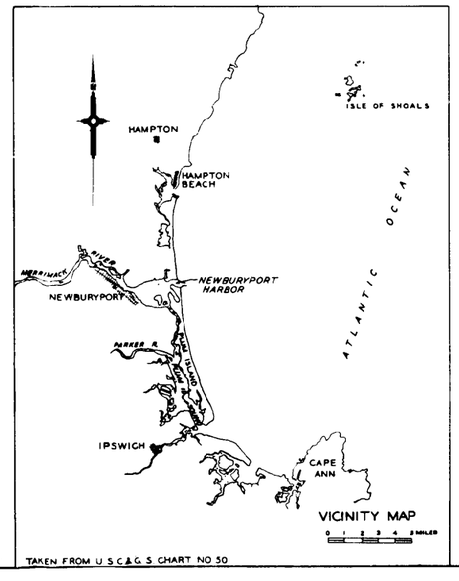
SHEET 2 OF 2 SHEETS.

PLATE E-2

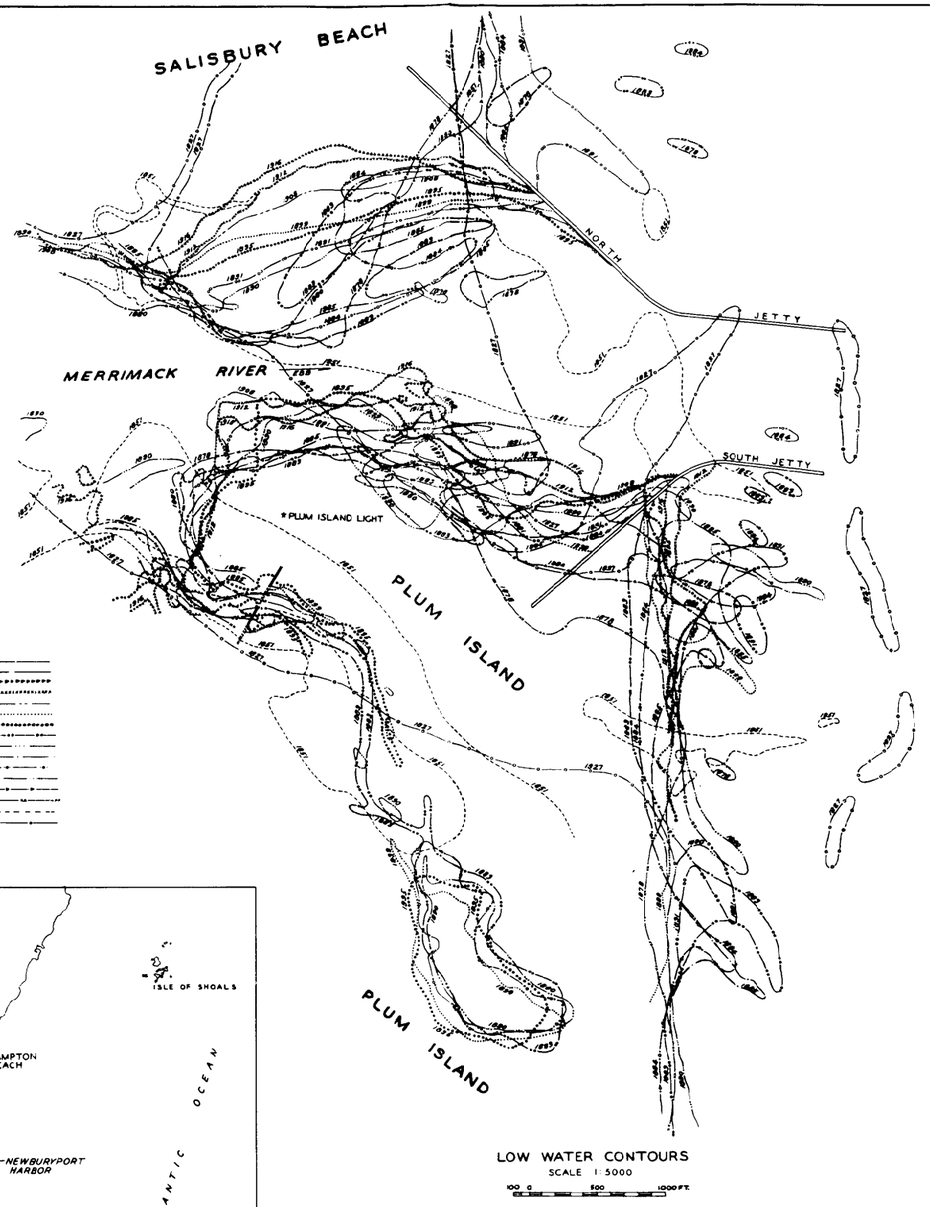


HIGH WATER CONTOURS
SCALE 1:5000
100 0 500 1000 FT.





TAKEN FROM U.S.C.&G.S. CHART NO. 50



LOW WATER CONTOURS
SCALE 1:5000
100 0 500 1000 FT.

BEACH EROSION CONTROL STUDY

PLUM ISLAND, MASS.

M.H.W. AND M.L.W. CHANGE MAP

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE E-3

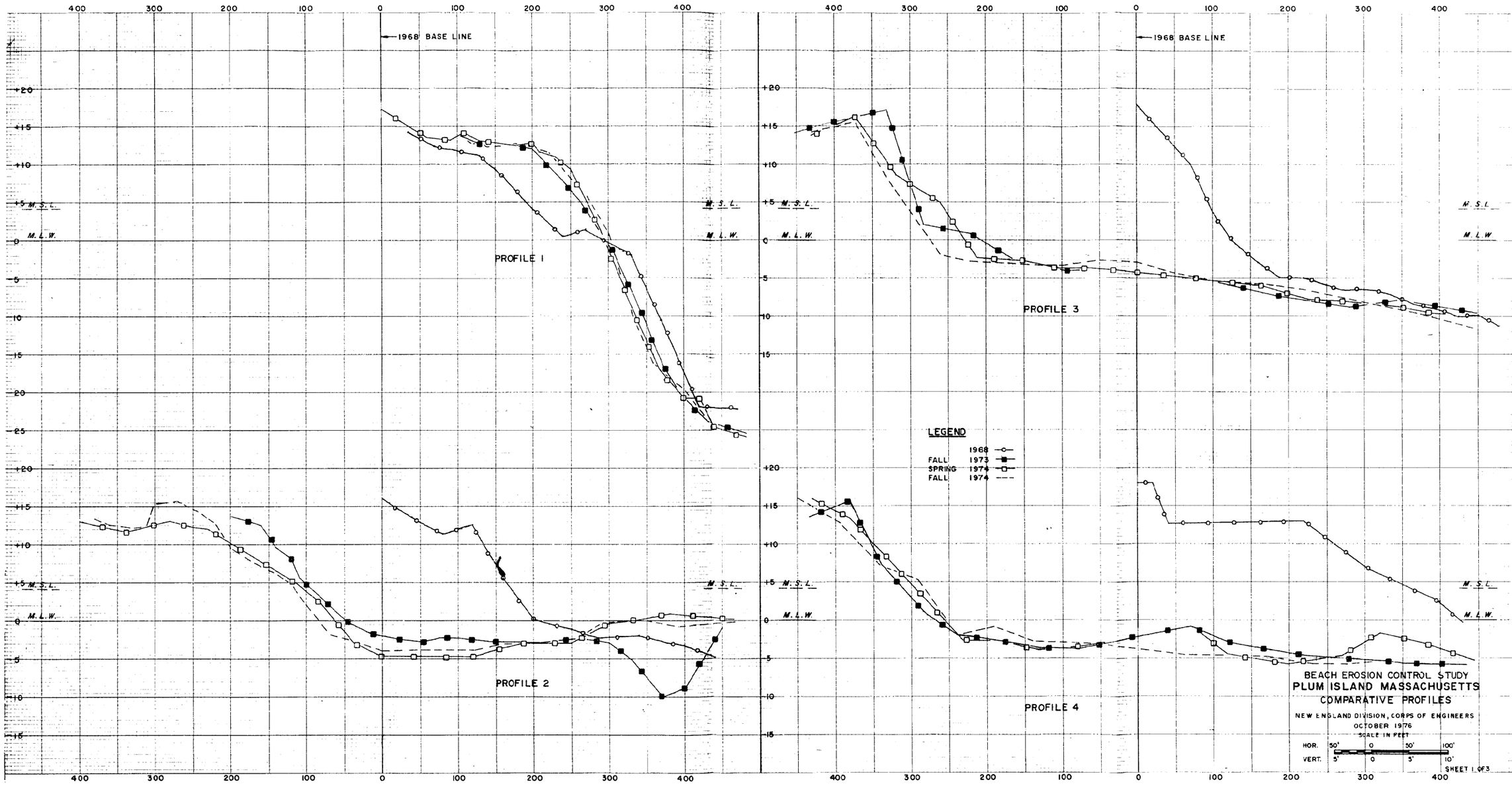

1968 BASE LINE
PROFILE 1
PROFILE 2
PROFILE 3
PROFILE 4
M.S.L.
M.L.W.
LEGEND
1968
FALL 1973
SPRING 1974
FALL 1974
BEACH EROSION CONTROL STUDY
PLUM ISLAND MASSACHUSETTS
COMPARATIVE PROFILES
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
OCTOBER 1976
SCALE IN FEET
HOR. 50' 0 50' 100'
VERT. 5' 0 5' 10'
SHEET 1 OF 3

PLATE E-4

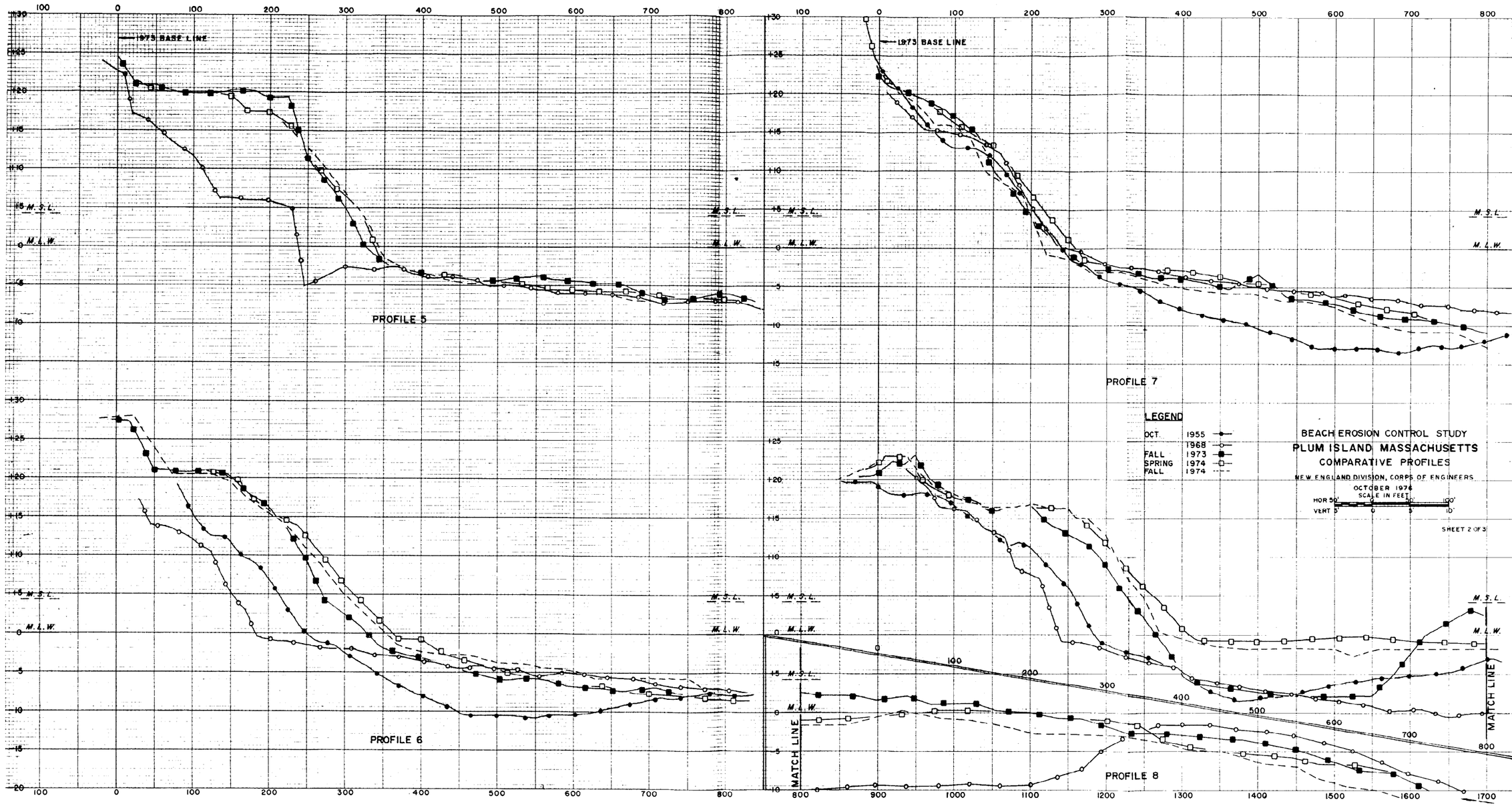

1973 BASE LINE
PROFILE 5
PROFILE 6
PROFILE 7
PROFILE 8
M.S.L.
M.L.W.
MATCH LINE
LEGEND
OCT. 1955
1968
FALL 1973
SPRING 1974
FALL 1974
BEACH EROSION CONTROL STUDY
PLUM ISLAND MASSACHUSETTS
COMPARATIVE PROFILES
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
OCTOBER 1976
SCALE IN FEET
HOR 50' 0 50' 100'
VERT 5' 0 5' 10'
SHEET 2 OF 3

PLATE E-5

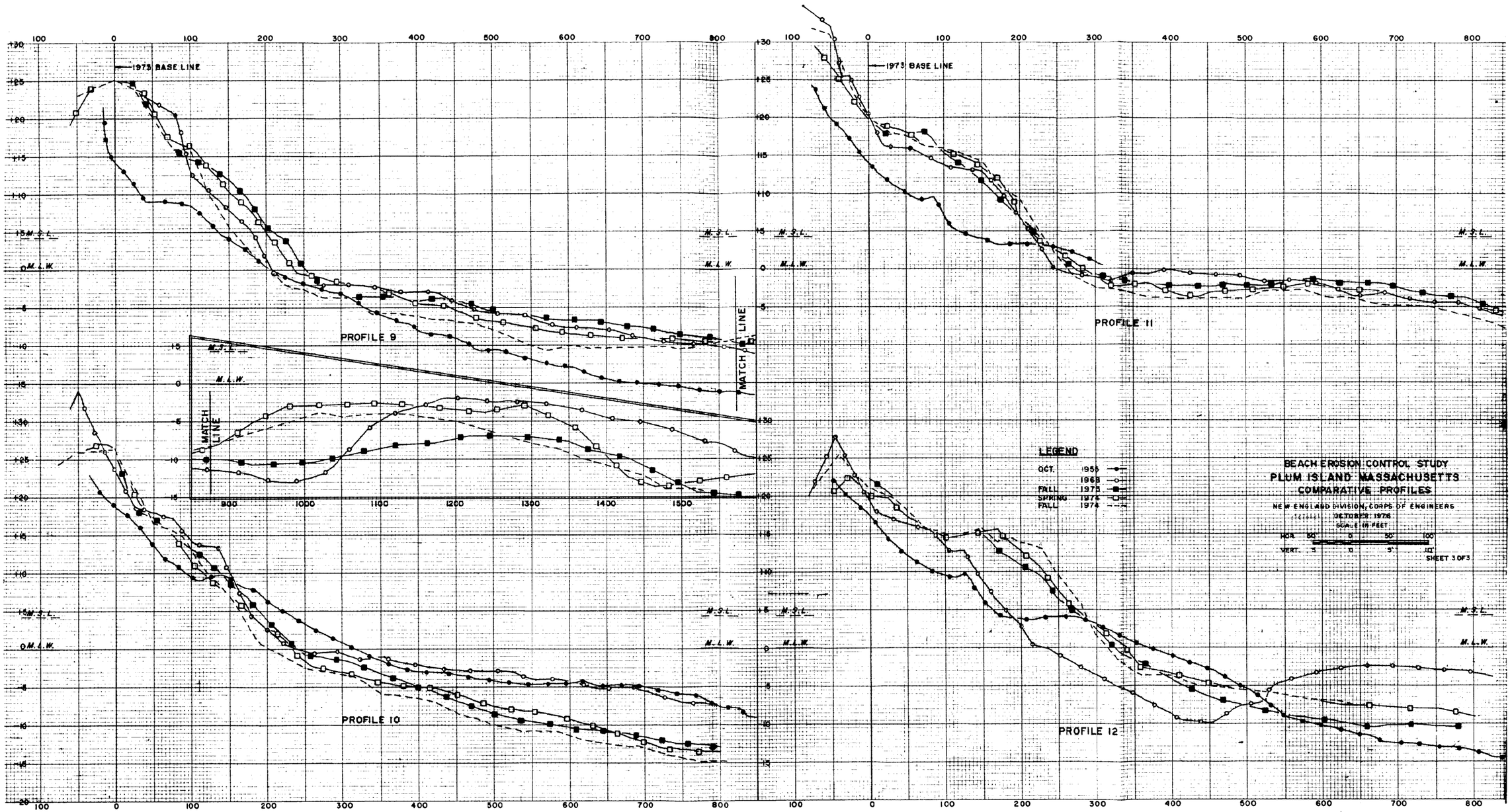

1973 BASE LINE
PROFILE 9
PROFILE 10
PROFILE 11
PROFILE 12
MATCH LINE
M.S.L.
M.L.W.
LEGEND
OCT. 1955
1968
FALL 1973
SPRING 1974
FALL 1974
BEACH EROSION CONTROL STUDY
PLUM ISLAND MASSACHUSETTS
COMPARATIVE PROFILES
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
OCTOBER 1976
SCALE IN FEET
HOR. 50' 0 50' 100'
VERT. 5' 0 5' 10'
SHEET 3 OF 3

PLATE E-6

APPENDIX F
COORDINATION WITH OTHER AGENCIES

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

The Commonwealth of Massachusetts
Department of Natural Resources
Division of Marine Fisheries
State Office Building, Government Center
100 Cambridge Street, Boston 02202

July 27, 1976

Col. John Mason
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Colonel Mason:

This Division has reviewed the various erosion control proposals for Plum Island. Based on the information we have received to date, we feel that the project will not be detrimental to Marine Fisheries resources.

Sincerely,

Frank Grice

Frank Grice, Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
New England Area Office
P. O. Box 1518
55 Pleasant Street
Concord, NH 03301

August 2, 1976

Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

Enclosed is our preliminary report on your Plum Island, Newbury and Newburyport, Essex County, Massachusetts, beach erosion control project.

Sincerely yours,

Melvin R. Evans

Melvin R. Evans
Field Supervisor, NEAO

Enclosure

PLUM ISLAND, NEWBURY AND NEWBURYPORT, ESSEX COUNTY, MASSACHUSETTS

Preliminary Report of the U. S. Fish and Wildlife Service on plans being developed for beach erosion control by the New England Division of the U. S. Army Corps of Engineers

August 2, 1976

A study is being carried out by the Corps of Engineers under the authority of a March 29, 1973, Resolution of the United States Senate. A reconnaissance report will be issued by the Corps of Engineers upon completion of this stage of study.

This report is submitted in partial fulfillment of provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and has been coordinated with the Massachusetts Division of Marine Fisheries and the National Marine Fisheries Service. Previous reports have been issued on beach erosion control projects at Plum Island by the Service on June 27, 1969, and March 22, 1973.

When a project plan is selected, the Service will prepare a Conservation and Development Report to fulfill provisions of the Coordination Act.

The information in this report may be utilized in preparation of an Environmental Impact Statement.

The study area extends from the Rowley-Newbury town line in the south to the Newburyport-Salisbury town line in the north. The limits of improvement extend from the north boundary of the main part of Parker River National Wildlife Refuge northward to the south jetty at the mouth of the Merrimack River.

Six alternative plans to control beach erosion have been developed. All plans include stabilization of the south shore of the Merrimack River entrance with a sand dike faced with armor stone revetment along 2,000 feet of the river shorefront.

The six alternative plans are summarized as follows:

1. Offshore stone breakwater about 1,500 feet offshore along the limits of improvement.

2. Rock revetment at an average bottom elevation of 3.0 feet above mean low water and a top elevation of 16.0 feet above mean low water along the limits of improvement.

3. Nearshore stone mound located about 300 feet seaward of the face of the dunes or houses with the same height and extent as Plan 2.

4. Placement of suitable sand fill along the shorefront along the limits of improvement.

5. A system of stone groins spaced 800 feet on center along the limits of improvement.

6. A combination of 4 and 5.

It is expected that Plans 1, 5, and 6 would provide the most fish and wildlife benefits. All would have the potential of supplying fishermen access and the large rock fill would provide habitat.

The area along the limits of improvement does not support significant terrestrial biological resources. The upper barrier beach is developed with vacation and year-round housing. The fore-beach portion of the project area undergoes continuous change due to the force of the wind and the sea, and therefore, supports few shellfish and other benthic resources. Numerous recreationally valuable finfish utilize the project area. Shore fishing takes place for species such as striped bass, bluefish, mackerel, cod, and flounder which are feeding just offshore.

The proposed alternatives are not expected to have adverse effects upon fish and wildlife resources. The alternatives including groins would provide additional fisherman access. The value of these benefits will be supplied by this Service if one of these alternatives is chosen. Potential adverse impacts caused by obtaining beach replenishment material can be minimized by carefully choosing the source. Alternative plan number 3 would cause adverse effects on recreational use of the beach.

In addition to the alternatives mentioned, the following alternatives should also be investigated:

1. No project.

2. Public acquisition over a long period of time of all private property on Plum Island.

The effects, if any, of the chosen alternative on Parker River National Wildlife Refuge must be clearly demonstrated. It must be demonstrated that any project along the limits of improvement will not cause decreased sand transport toward the refuge beaches or increase erosive forces in that direction.

The U. S. Fish and Wildlife Service, therefore, recommends:

1. The location of the sand source be coordinated with this Service, the National Marine Fisheries Service, the Massachusetts Division of Marine Fisheries, and the Massachusetts Division of Fisheries and Game.

2. The cross sectional configuration of the groins and offshore breakwater be developed to allow maximum potential fisherman access.

3. The two new alternatives listed above be investigated.

Sincerely yours,

Melvin R. Evans

Melvin R. Evans
Field Supervisor, NEAO

EVELYN F. MURPHY
SECRETARY

The Commonwealth of Massachusetts
Executive Office of Environmental Affairs
100 Cambridge Street
Boston, Massachusetts 02202

December 15, 1976

Mr. Joseph L. Ignazio
Chief, Planning Division
NED, U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Ignazio:

The Executive Office of Environmental Affairs has reviewed the New England Division's preliminary feasibility report for erosion control on Plum Island Beach, Newburyport-Newbury, Massachusetts. This office concurs with your agency's findings that the proposed alternatives discussed in the study are not economically justified. However, we feel that there is one alternative that can be justified economically and should be pursued. Sand that is dredged for maintenance purposes from the Merrimack River tidal inlet should be used to nourish the critically eroding areas of Plum Island Beach. In addition, the Commonwealth of Massachusetts encourages the U.S. Army Corps of Engineers to adopt a policy that encourages use of clean dredged material for beach nourishment and engineering purposes whenever it is possible. The Commonwealth is willing to work with the Corps to ensure that clean dredge material is used with maximum public benefit and minimal environmental harm.

Although we recognize that the report represents only a preliminary feasibility study of a very complex issue, we are concerned that the report does not include an analysis of the comparative effectiveness of the proposed engineering structures, nor does it address potential adverse environmental effects, such as increased erosion of adjacent coastal areas. By the absence of such discussion, the report implies, in fact, that all of the proposed structures would be equally effective in curbing erosion and that other areas along the coast would not be adversely affected by major alteration of coastal processes such as proposed. We would hope that in future feasibility reports these concerns will be addressed, not only because they are important concerns independent of economic values, but because consideration of them early on may well influence the cost feasibility of proposed alternatives.

Thank you for allowing this agency the opportunity to review this preliminary draft.

Sincerely yours,

Evelyn F. Murphy
Secretary of Environmental Affairs

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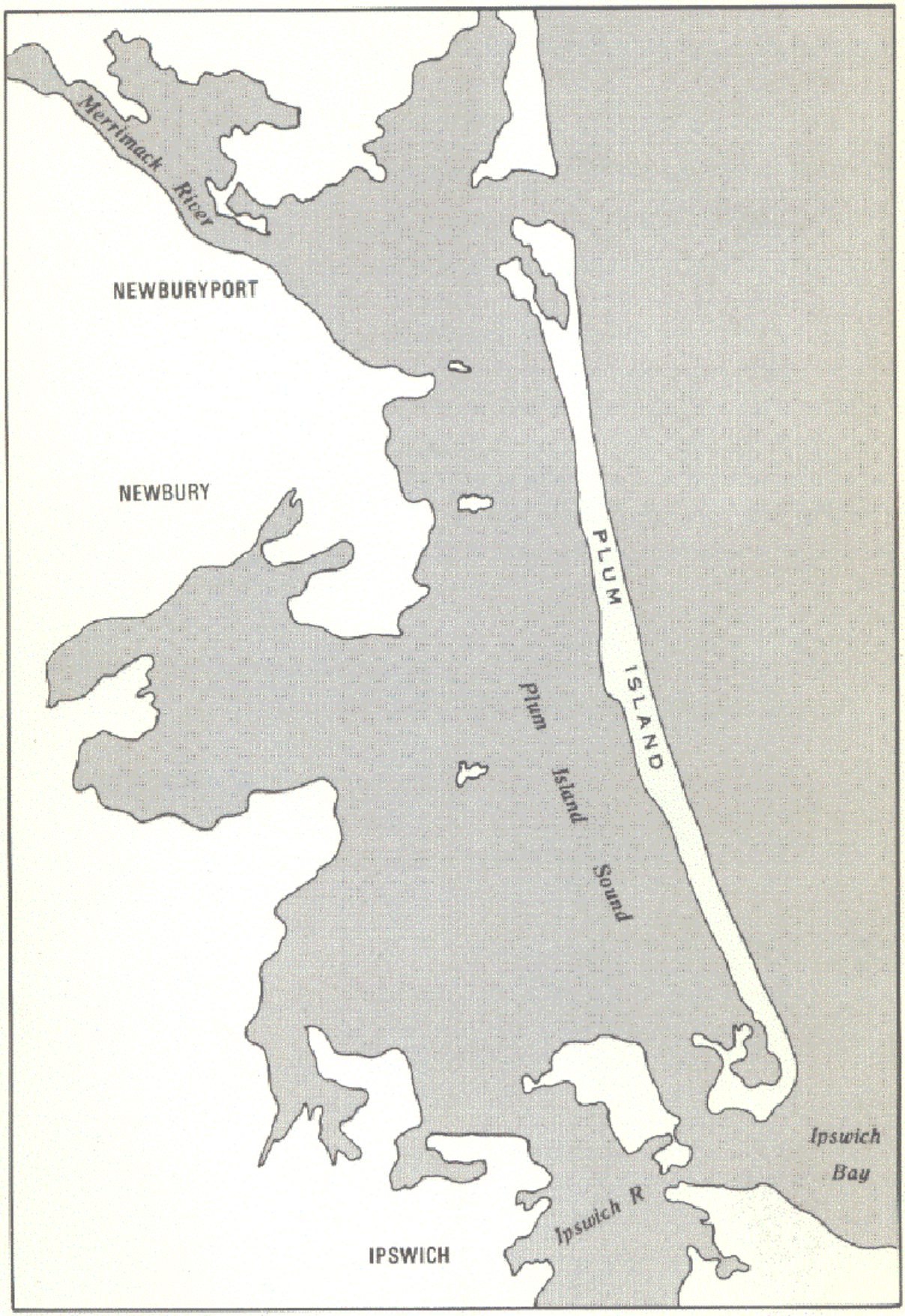
Merrimack River
NEWBURYPORT
NEWBURY
PLUM ISLAND
Plum Island Sound
Ipswich Bay
Ipswich R
IPSWICH